

Sixth Edition

Orofacial Pain

Guidelines for
Assessment, Diagnosis,
and Management

The American Academy of Orofacial Pain

Edited by Reny de Leeuw, DDS, PhD, MPH
and Gary D. Klasser, DMD

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Guidelines for Assessment, Diagnosis, and Management, Sixth Edition

American Academy of Orofacial Pain

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Preface

The American Academy of Orofacial Pain (AAOP) was founded in 1975, and its goal was to improve the understanding and quality of education in temporomandibular disorders (TMDs) and orofacial pain. The mission of the AAOP remains to be an organization of health care professionals dedicated to alleviating pain and suffering through the promotion of excellence in education, research, and patient care in the field of orofacial pain and associated disorders.

Five publications have preceded this current edition of what commonly is referred to as the *AAOP Guidelines*. Dr Charles McNeill spearheaded the first two editions called *Cranio-mandibular Disorders: Guidelines for Evaluation, Diagnosis, and Management*, (Quintessence, 1990) and *Temporomandibular Disorders: Guidelines for Classification, Assessment, and Management* (Quintessence, 1993). These publications focused predominantly on TMDs. As health care professionals and researchers became more conscious of the relationship between TMDs and other disorders of the head and neck, there was a need to expand the *Guidelines* to include disorders presenting as or related to TMDs. These disorders included not only headaches and neck disorders but several neuropathic pain conditions as well as biobehavioral factors. In 1996, under the editorship of Dr Jeffrey Okeson, the third version of the *AAOP Guidelines* was published, titled *Orofacial Pain: Guidelines for Assessment, Diagnosis, and Management*. That edition used the term *orofacial pain* to echo the rapidly changing and expanding field of orofacial pain and to reflect the fact that TMDs and orofacial pain should not be regarded as separate conditions, but that TMDs should be considered part of the disorders that fall under the umbrella of orofacial pain. Under the editorship of Dr Reny de Leeuw, the fourth edition of the *Guidelines* was published, which started to express evidence-based concepts. This edition included a separate chapter on cervical disorders to emphasize the close relationships between some orofacial pain disorders and cervical pain disorders, and—more importantly—to call attention to the differences and similarities associated with these disorders. The fifth edition, published

in 2013, adopted the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) and the expanded TMD taxonomy based on the work of the International RDC-TMD Consortium. An updated definition of bruxism based on another international consensus work group was also adopted. Moreover, a new chapter was added in the fifth edition dedicated to the relationship between pain disorders and sleep.

While the structure of the present work resembles previous editions, significant changes have been implemented in this current edition. All chapters contain essential updates, and some have undergone more changes than others. References have been updated throughout to reflect the most current literature. When available, evidence-based material has been included to provide the reader with scientifically sound and effective diagnostic procedures and treatment options. All references to the *International Classification of Diseases, Ninth Edition (ICD-9)* codes have been removed, and *ICD-10* codes have been updated or added. In addition, references to the International Classification of Headache Disorders, third edition (beta version) (ICHD) have been updated in chapters 4 and 5 and added to chapter 6. Chapter 1 has been updated with the most recent knowledge from the Orofacial Pain: Prospective Evaluation and Risk Assessment (OPPERA) studies, regarding genetics and epigenetics as well as expanded information about glial cells, neuropeptides, and their implications for pain. In chapter 2, the relationship between TMDs and otalgia has been elaborated upon, and additional measures for sleep apnea assessment have been included. In chapter 3, the newest versions of classification systems have been included. Chapters 4 and 5 contain various general updates as well as updates to management. Chapter 6 was completely renewed and now follows the ICHD. As a result, the description of superior laryngeal neuralgia was eliminated. Chapter 7 contains general updates to the references as well as management strategies for several disorders. The sections on viral infections, candidiasis, and pain due to cancer treatment contain the most notable updates. In chapter 8, the section on epidemiology was updated and expanded to

include more information on TMDs and comorbid conditions. The section on genetic factors has also been updated to reflect the work from the OPPERA studies. The section on diagnostic classification has been updated to more accurately describe the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) for the most common TMDs and the expanded taxonomy including less common TMDs. General updates have been provided for the management section of this chapter, and new sections include but are not limited to gabapentinoids, glucosamine and chondroitin, and topical medications. A summary of pharmacologic treatments is also new. Under the physical agents section, a separate paragraph is dedicated to the potential use of botulinum toxin for myofascial pain, indicating that there is currently insufficient evidence for its use. The layout for chapter 9 has been changed, and sections emphasizing genetics and peripheral and central sensitization have been added. Sections have also been renamed to reflect the most up-to-date terminology. In chapter 10, benign disorders of the eyes and ears have been expanded on. A description of first-bite syndrome has also been added. The descriptions of various connective tissue diseases have undergone major edits, and the section on blood vessels contains major improvements as well. The content of chapter 11 has been updated, specifically regarding comorbidities and bruxism. Chapter 12 provides updates on brief, ultra-brief, and comprehensive screening tools for biobehavioral factors in line with the recommendations from the DC/TMD. The chapter also includes major updates in the description of several psychiatric diseases in line with the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5)*. Lastly, the glossary has undergone major updates to reflect the emerging and expanding field of orofacial pain. New terms have been added, and obsolete and superfluous terms have been removed.

Finally, a word of caution: This is not intended to be an all-encompassing textbook including complete details regarding all aspects of orofacial pain. Instead, it is meant to provide insight in and to assist the reader with the procedures of evidence-based assessment, diagnosis, and management of orofacial pain conditions, based on the latest scientific knowledge.

Reny de Leeuw and Gary D. Klasser
Co-chairs, AAOP Guidelines Committee

Acknowledgments

Over the years, numerous AAOP members and nonmembers have participated in the evolution of the *AAOP Guidelines*, resulting in the sixth edition of this publication. The contributors to the current edition of the *AAOP Guidelines* are listed on a separate page. Each new edition has reflected the emerging and expanding field of orofacial pain. Based on these developments, new and evidence-based materials have been added. However, this ever-evolving work has built on and edited the work others have done in the past. As such, some parts of previous contributions may still be intact. We therefore want to extend our sincere appreciation to all of you who have contributed to any of the past editions, and especially to those of you who laid the foundation of this publication. We also would like to offer much gratitude to the publishers for providing us with timely advice and guidance so that deadlines could be met. The staff support at Quintessence has been incredibly accommodating and meticulous in their efforts and should be applauded. We truly hope that you will get great enjoyment and practical help from this new edition.

Introduction to Orofacial Pain

1

Key Points

- ◇ Orofacial pain remains a prevalent and debilitating condition with significant social and economic impacts.
- ◇ Many of the risk factors associated with a temporomandibular disorder (TMD) involve mechanical, chemical, or environmental stressors that increase the likelihood of developing and maintaining a chronic pathologic state.
- ◇ TMDs are not caused by a single gene mutation but are a result of changes in the expression of many genes that contribute to the pathology and nature of the pain.
- ◇ Sensitization and activation of trigeminal nerves and the subsequent development of peripheral and central sensitization are key pathophysiologic events that lead to allodynia and hyperalgesia.
- ◇ A decade of discovery from the Orofacial Pain: Prospective Evaluation and Risk Assessment (OPPERA) study helped to clarify specific risk factors and genes implicated in the development of a TMD.
- ◇ Given the complex nature of orofacial pain conditions, treatment should involve multiple modalities including pharmaceuticals, physical therapy, behavioral modifications, diet, and exercises that emphasize proper breathing and increasing flexibility.

Orofacial pain refers to pain associated with the hard and soft tissues of the head, face, and neck. These tissues, whether skin, blood vessels, teeth, glands, or muscles, send impulses through the trigeminal nerve to be interpreted as pain by the brain circuits that are primarily responsible for the processing that controls complex behavior.¹ The complaint of orofacial pain encompasses a diagnostic range from neurogenic, musculoskeletal, and

psychophysiologic pathology to headaches, cancer, infection, autoimmune phenomenon, and tissue trauma. Evaluation and management of orofacial pain requires collaboration among all fields of medicine because pain has the potential to arise from multiple trigeminal receptive fields.

The quest to better manage pain problems involving the trigeminal system such as TMDs and headaches has led to the establishment of orofacial pain as a discipline in the field of dentistry. There are residency training programs in orofacial pain, board certification processes, and increasing cooperation among advocacy groups, universities, professional organizations, and federal agencies. A huge step in the recognition of orofacial pain as a discipline in dentistry occurred in 2009 when the Commission on Dental Accreditation (CODA) approved orofacial pain as an area of advanced education. Since 2011, several programs in the United States have received accreditation from CODA. Furthermore, the International Association for the Study of Pain developed a core curriculum on this subject for all health care professionals in a clear acknowledgment of the need for orofacial pain as a component of professional education.²

This revised edition is a collaborative effort derived from reviews of refereed literature spanning the spectrum of conditions that are at the root of orofacial pain. It is intended for health care professionals who evaluate and treat patients with orofacial pain and face the daunting task of keeping up with the literature in the rapidly emerging arena of pain management in clinical practice.

The Health Care Professional's Responsibility in Orofacial Pain

It is every clinician's responsibility to remain unbiased during evaluation and differential diagnosis. Orofacial pain complaints involve diverse, complex physiologic interrelationships,

and all clinicians must be able to judge when their diagnostic acumen requires consultation; otherwise, treatment may not target the appropriate source.

The clinician's responsibility is threefold. First, the clinician must combine a current working knowledge of the clinical science of orofacial pain with an ability to obtain a complete relevant history from the patient. Appropriate questions must be asked, answers must be analyzed, and findings must be synthesized into an initial differential diagnosis. Second, the clinician must perform a thorough clinical assessment, including a physical examination and indicated laboratory testing, imaging studies, neurologic testing, and consultations. Accurate diagnosis may require insight from other health care professionals. Third, the clinician must be able to explain to the patient all findings as well as the details of the treatment plan, which must be consistent with standards of care based on scientific literature. When the scope of care falls beyond individual expertise, an interdisciplinary team approach may be developed. The clinician should discuss appropriate referral options with the patient.

Epidemiology of Orofacial Pain

Pain is a common experience that has profound societal effects. Results from a cross-sectional Internet-based survey found that the weighted point prevalence of chronic pain was 30.7% in adults in the United States.³ This prevalence was greater in women and increased with age.³ Based on results obtained from the 2012 National Health Interview Survey, the National Center for Complimentary and Integrative Health from the National Institutes of Health (NIH) reports that nearly 50 million American adults suffer from significant chronic or severe pain. Not surprisingly, the study found that individuals in more severe pain required more health care services and experienced greater disability when compared with individuals re-

porting lower levels of pain. About half of the individuals in the worst pain still reported their overall health as good or better, while both sex (women) and ethnicity (non-Hispanics) were associated with a higher frequency of reporting painful conditions. Findings from this report highlight the need for a better appreciation of the subjective nature of pain and the challenge of personalizing the treatment to achieve a successful outcome for each pain patient.

Chronic pain costs the United States billions of dollars annually due to loss of work, decreased productivity, disability compensation, and expenses for health care services including more emergency room visits, higher medication costs, and greater psychologic treatment expense.⁴ Chronic pain is economically costly because it requires medical intervention and makes it more difficult to treat other ailments. The cost of pain is actually estimated to be greater than the annual costs of heart disease, cancer, and diabetes.⁵

Lipton et al⁶ surveyed 45,711 American households and reported that nearly 22% of the general population had experienced at least one of five types of orofacial pain in the past 6 months. The most common type of orofacial pain was toothache, reported by 12.2% of the population. Temporomandibular joint (TMJ) pain was reported by 5.3%, with face or cheek pain being reported by 1.4%. Orofacial pain seldom appears to be an isolated complaint. More than 81% of patients reporting to an orofacial pain center had pain sources apart from the trigeminal system, but few patients mention these other pain sources.^{7,8} Conditions that seem to coexist with TMDs include fibromyalgia (FM), chronic fatigue syndrome, headache, panic disorder, gastroesophageal reflux disorder, irritable bowel syndrome (IBS), multiple chemical sensitivity, and posttraumatic stress disorder.^{9,10} Symptoms of such comorbid conditions differentiate orofacial pain patients from those who seek routine dental care.¹¹ If the true pain sources are not revealed during

the evaluation, the prognosis may be adversely affected by the continued barrage of brain circuits as the result of chronic nociception.

Results have been published from the OPPERA study funded by the National Institute of Dental and Craniofacial Research (NIDCR) to identify risk factors involved in the initiation and maintenance of TMDs and to develop treatments for managing TMD-associated pain. The major objectives of this longitudinal, multidisciplinary study were to determine psychologic and physiologic risk factors, clinical characteristics, and associated genetic and cellular mechanisms that influence the development of TMDs. Based on findings from these studies, the investigators presented a model that includes genetic, physiologic, and environmental factors that increase the risk for an individual to experience TMD pathology (Fig 1-1). More recently, NIDCR funded an additional study, OPPERA II, with the goal of further investigating risk factors for the development of TMDs and understanding their relationship with often-reported comorbid pain conditions including IBS, headache, and lower back pain. A summary of the major findings from a decade of research from the OPPERA studies has recently been published.^{12,13} Those individuals seeking more information from the OPPERA studies are encouraged to visit the *Journal of Pain* website.

Importantly, both the US Congress and NIH now recognize coexisting pain conditions characterized by a set of disorders that include, but should not be limited to, TMDs, FM, vulvodynia, IBS, interstitial cystitis/painful bladder syndrome, endometriosis, chronic tension-type headache, migraine headache, myalgic encephalomyelitis/chronic fatigue syndrome, and chronic lower back pain.¹⁴ Taken together, these conditions are gradually being referred to as *chronic overlapping pain conditions*. The discussion of these overlapping pain conditions produced by the Chronic Pain Research Alliance can be found at their website.

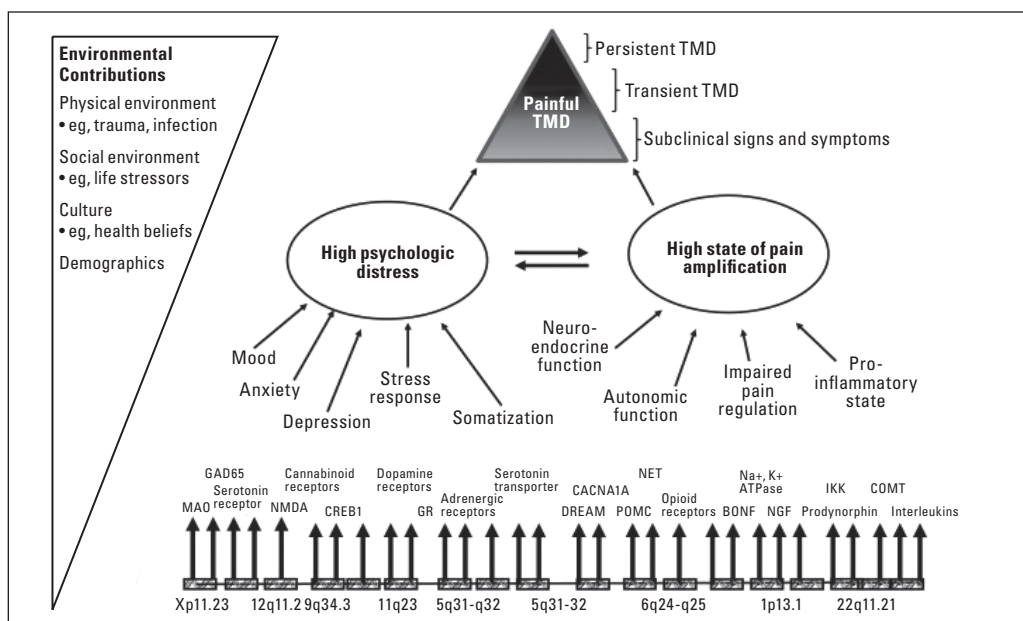


Fig 1-1 Overview of major factors that contribute to development of TMD pathology and the associated genes. (Reprinted with permission from Slade et al.¹²)

Pain constructs

Pain is defined as “an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage.”¹⁵ *Nociceptors* are polymodal, high-threshold nerve endings that send impulses in response to damaged tissue on fast-conducting A δ fibers and slow-conducting C-fibers to the central nervous system (CNS). Although pain is an interpretation of nociception, many orofacial pain patients lack apparent tissue damage, and anatomical changes such as TMJ disc displacement without reduction do not predict continuing pain.^{16,17}

About 25% of free nerve endings in skeletal muscle that transmit impulses to the CNS on A δ fibers and C-fibers are chemo- and mechanoreceptive but not nociceptive.¹⁸ Some of these low-threshold receptors, called *metaboreceptors*, appear to be uniquely stimulated by the metabolic products generated during

muscle activity, while others sense the relative distension of post-capillary bed venules.^{19–21} These receptors display background activity at rest, accelerate impulse transmission as behavior intensity increases, and may affect the same central modulatory systems as nociception.^{21–24} The CNS uses this input to coordinate respiratory and cardiovascular changes during dynamic muscle behavior.^{19,21–23} Future consideration of the role of these receptors in pain etiology may help us better understand pain conditions in which there is no apparent tissue damage.

Anatomical and Physiologic Considerations of Orofacial Pain

Orofacial pain may be defined as pain and dysfunction affecting motor and sensory transmission in the trigeminal nerve system.²⁵ From a sensory perspective, the trigeminal system

oversees the efficacy and tissue integrity of the highly integrative orofacial behaviors that are controlled by cranial nerves and modulated by the autonomic nervous system (ANS) and the greater limbic system.²⁶ Orofacial nerves transmit information about pressure (touch), position, temperature, and potential pain to the trigeminal nuclei, which have extensive bidirectional connections throughout the brain.^{27–29} These trigeminal connections affect the sensory, motor, and autonomic-endocrine changes that occur during orofacial behaviors, and orofacial pain may result when these behaviors are impaired. The next sections briefly discuss peripheral and central trigeminal neuroanatomy to explain how the trigeminal system affects physiology and pain.

Neuroanatomy of the orofacial structures

Cranial nerves are extensions of the brain that directly or indirectly innervate tissues involved with the trigeminal system.⁴ The specialized neurons of the olfactory, optic, and vestibulocochlear nerves that send smell, sight, sound, and balance information to the CNS do not travel through the trigeminal nuclei. However, nerves associated with the nose, eye, and ear tissues do transmit proprioceptive, pressure, and potential pain impulses into the trigeminal nuclei. A comprehensive orofacial pain evaluation should include a basic assessment of the function of all cranial nerves (see chapter 2). Five of these nerves (V, VII, IX, X, and XII) are reviewed here.

Trigeminal nerve

The trigeminal nerve, which provides sensory innervation to most of the head and face, is the primary nerve involved in TMDs, migraine, sinus, pulpal, and periodontal pathology. It is the largest cranial nerve and consists of three peripheral divisions: the ophthalmic, maxillary, and mandibular.^{30–33} These branches receive sensory input that is conveyed on first-order neurons through the trigeminal ganglion,

where most neuronal cell bodies are located. Although these neurons enter the ganglion on three branches, they exit in one large sensory root that enters the brainstem at the level of the pons before reaching the trigeminal nuclei.³⁴

Ophthalmic branch (V1). This branch of the trigeminal nerve leaves the skull through the superior orbital fissure and transmits sensory information from the scalp and forehead, upper eyelid, conjunctiva and cornea of the eye, nose (including the tip of the nose), nasal mucosa, frontal sinuses and parts of the meninges (the dura and blood vessels), and deep structures in these regions. It also carries postganglionic parasympathetic motor fibers to the glands and sympathetic fibers to the pupillary dilator muscles.³⁴

Maxillary branch (V2). This branch exits the skull at the foramen rotundum. It has a sensory function for the lower eyelid and cheek; the nares and upper lip; the maxillary teeth and gingiva; the nasal mucosa; the palate and roof of the pharynx; the maxillary, ethmoid, and sphenoid sinuses; and parts of the meninges. Near its origin, it divides to form the middle meningeal nerve, which supplies the middle meningeal artery and part of dura mater. The terminal V2 branches—the anterior and greater palatine nerves and the superior, middle, and anterior alveolar nerves—innervate the soft palate, uvula, hard palate, maxillary gingiva and teeth, and mucous membranes of the cheek.³⁴

Mandibular branch (V3). This branch leaves the skull through the foramen ovale and functions in both sensory and motor transmission. V3 carries sensory information from the lower lip, mandibular teeth and gingiva, floor of the mouth, anterior two-thirds of the tongue, the chin and jaw (except the angle of the jaw, which is supplied by C2 and C3), parts of the external ear, parts of the meninges, and deep structures. The auriculotemporal nerve is a branch of V3 that innervates most of the TMJ. The motor nuclei use V3 to provide motor fibers to the muscles of mastication (ie, mas-

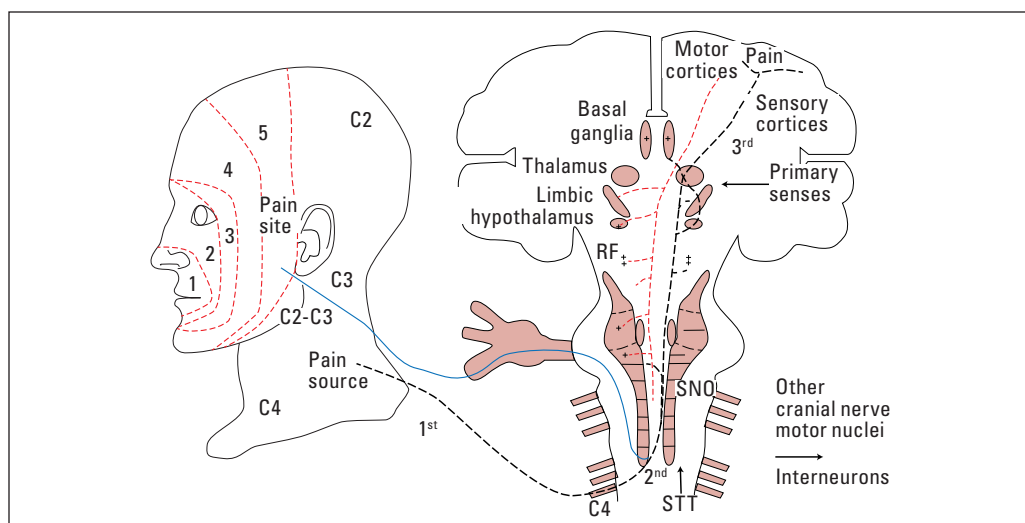


Fig 1-2 Sensory pathways and motor response to referred pain. The first-order neurons from a pain site in facial lamina 5 and from the pain source in the C4 receptive field each converge on lamina 5 of the subnucleus caudalis and excite the same second-order neurons. As these second-order neurons ascend, they arborize with the subnucleus oralis and subnucleus interpolaris (not shown) and many reticular formation structures before synapsing with third-order neurons in the thalamus. The third-order neurons are thalamo-cortico-basal ganglia-limbic circuits that interpret pain and generate the descending motor and pain modulatory reactions to pain interpretation. The descending motor neurons also arborize with reticular formation locations and connect, via interneurons, to the trigeminal motor nucleus and to all cranial nerve motor nuclei. Note that trigeminal input is never analyzed in isolation because primary sensory and spinal thalamic tract input is also constantly presented to the brain for analysis. RF, reticular formation structure; SNO, subnucleus oralis; STT, spinal thalamic tract.

setter, temporalis, medial pterygoid, lateral pterygoid, anterior digastric, and mylohyoid) as well as the tensor veli palatini involved with Eustachian tube function and the tensor tympani, which attaches to the malleus bone in the eardrum.³⁴

Trigeminal sensory nuclei. The trigeminal sensory nuclei lay in bilateral columns on either side of the brainstem. They originate in the midbrain and terminate in the dorsal horn of the cervical spinal cord (Fig 1-2). All touch, position, and temperature sensory input from the face is sent to the trigeminal nuclei, as is potential pain input from the face, head, and neck.⁴ They are, in a rostrocaudal orientation, the mesencephalic nucleus, the main sensory nucleus, and the spinal trigeminal nucleus.

The *mesencephalic nucleus*, which is more a ganglion than a nucleus, houses the cell bodies of the proprioceptive neurons that convey input from the apical periodontal ligament and the muscle fibers that contract during the jaw-closing reflex. These proprioceptive neurons and possibly the blink reflex nerves represent the only peripheral nerves with cell bodies located within the CNS.^{4,35} The neurons are monosynaptic and pass through the mesencephalic nucleus to synapse in the trigeminal motor nuclei located medially to the much larger main sensory nucleus. The *main sensory nucleus* receives the facial proprioceptive and pressure input for orofacial behaviors (eg, chewing, kissing, smiling, and light touch) other than the jaw-closing reflex.

These neurons have their cell bodies in the trigeminal ganglion and synapse in the main sensory nucleus, where input is conveyed to the motor nuclei by arrays of small interneurons.⁴ The *spinal trigeminal nucleus* consists of three subnuclei: subnucleus oralis, subnucleus interpolaris, and subnucleus caudalis. Subnucleus oralis and subnucleus interpolaris receive some peripheral nociceptive fibers, but they mostly receive temperature information on A δ fibers and touch impulses on A β fibers from the periphery and convey this input via interneurons to the motor nuclei.⁴ In response to nociceptor activation, neuropeptides and other inflammatory agents are released in the spinal trigeminal nucleus and can cause excitation of neurons and glial cells. This promotes development of central sensitization, allodynia, and hyperalgesia, which are physiologic events associated with acute and chronic pain.^{36,37}

The subnucleus caudalis is the main terminus for most slow first-order neurons that convey potential pain from trigeminal receptive fields. Figure 1-2 illustrates the “onion peel” somatotopic organization of the face (areas 1 to 5) and the corresponding laminae (1 to 5) in the subnucleus caudalis, where first-order nociceptive neurons terminate regardless of their division of origin.⁴ For instance, A- and C-fiber neurons from area 5 in the face all synapse with second-order nociceptive neurons in the most caudal aspect of the subnucleus caudalis, lamina 5, whether they start in V1, V2, or V3. Such convergence means that a dural blood vessel, masseter muscle, or a tooth or tongue nociceptive afferent could excite the same second-order neurons.

This convergence, the anatomical basis for referred pain, is not just a facial phenomenon. Cervical spine nociceptive afferents also synapse in the subnucleus caudalis, meaning that trapezius or sternocleidomastoid nociceptive afferents can excite second-order neurons that also receive input from facial tissues.^{28,29,38} Recent findings from the OPPERA study have provided evidence that pain in the neck and

shoulder muscles is highly correlated with both acute and chronic TMDs. Thus, this type of neuronal organization may help to explain the high prevalence of comorbid pain conditions associated with tissues in the head and face (eg, headache and sinusitis, headache and TMDs). Another construct to consider is that all of the CNS structures affected by trigeminal nociceptive input are also contacted by second-order neurons from the dorsal horn of the spinal cord.¹⁵ Therefore, potential pain input from regions outside trigeminal receptive fields may excite CNS structures that communicate with trigeminal nuclei and modulate their functions.

Facial nerve

The seventh cranial nerve is a mixed nerve that has five branches (temporal, zygomatic, buccal, mandibular, and cervical) that course through the parotid gland but do not innervate the gland. Its main function is motor control of most of the muscles of facial expression and the stapedius muscle of the middle ear. The facial nerve supplies parasympathetic fibers to the sublingual and submandibular glands via the chorda tympani and to the lacrimal gland via the pterygopalatine ganglion. In addition, it conveys taste sensations from the anterior two-thirds of the tongue to the solitary tract nucleus and transmits cutaneous sensation from the skin in and around the earlobe via the intermediate nerve.³⁴

Glossopharyngeal nerve

The ninth cranial nerve is a mixed nerve comprising somatic, visceral, and motor fibers. It conveys sensory information from the posterior third of the tongue, tonsils, pharynx, middle ear, and carotid body. Taste sensation from the posterior third of the tongue as well as carotid body baroreceptor and chemoreceptor information are transmitted to the solitary tract nucleus. Nociceptive input from the ear is sent to the spinal trigeminal nucleus. From the inferior salivatory nucleus, the glossopharyn-

geal nerve delivers parasympathetic control to the parotid and mucous glands throughout the oral cavity, while motor fibers from the nucleus ambiguus project to the stylopharyngeus muscle and upper pharyngeal muscles. An altered gag reflex indicates glossopharyngeal nerve damage.³⁴

Vagus nerve

The tenth cranial nerve originates in the brainstem and extends to the abdomen and innervates virtually all organs from the neck to the transverse colon except the adrenal glands. It supplies visceral afferent fibers to the mucous membranes of the pharynx, larynx, bronchi, lungs, heart, esophagus, stomach, intestines, and kidneys, and it distributes efferent or parasympathetic fibers to the heart, esophagus, stomach, trachea, bronchi, biliary tract, and most of the intestine. The vagus nerve also affects motor control of the voluntary muscles of the larynx, pharynx, and palate and carries somatic sensory fibers that terminate in the skin of the posterior surface of the external ear and the external acoustic meatus.³⁴ Through these connections, the vagus affects activities as varied as respiration, cardiac function, sweating, digestion, peristalsis, hearing, and speech.

Spinal accessory nerve

The eleventh cranial nerve innervates the cervical muscles, the sternocleidomastoid and trapezius, which are coactivated during masticatory behaviors. Like the trigeminal motor nucleus, the accessory motor nuclei are rich in norepinephrine receptors, which can facilitate vigilant behaviors.³⁹ Nociceptive afferents from the cervical muscles converge onto the spinal trigeminal nucleus. It is notable that cervical myofascial pain seems to be prominent in patients with orofacial pain.

Upper cervical nerves

Spinal nerves C1 to C4 and possibly C5 are important considerations in orofacial pain because their sensory fibers converge onto the

trigeminal subnucleus caudalis.^{28,29,38} As C1 to C4 leave the spine, they combine to form the cervical plexus, which yields cutaneous, muscular, and mixed branches. C1 forms the suboccipital nerve that supplies motor control to the muscles of the suboccipital triangle. The cutaneous branches are the lesser occipital (C2, C3), the greater auricular (C2, C3), the transverse cervical (C2, C3), and the supraclavicular (C3, C4). These nerves innervate the back of the head and neck, the auricle and external acoustic meatus, the anterior neck and angle of the mandible and the shoulders, and the upper thoracic region. The muscular branch—the ansa cervicalis—innervates the sternohyoid, the sternothyroid, and the omohyoid muscles and is composed of a superior root (C1, C2) and an inferior root (C2, C3). The mixed branch is the phrenic nerve (C3, C4, and C5), which innervates the diaphragm.³⁴

Autonomic nervous system

The ANS, which is commonly viewed as a largely involuntary motor system, is composed of three peripheral divisions—the sympathetic, parasympathetic, and enteric—that function to maintain homeostasis.³⁴ The peripheral ANS is controlled by the central ANS, which comprises cortical, limbic, and reticular formation structures and nuclei.³⁹ Stimuli that activate the central ANS induce increased sympathetic activity initially in the brainstem and then in the periphery.^{39,40} The sympathetic system is involved in vigilance, energy expenditure, and the flight-or-fight response, while the role of the parasympathetic system is to counterbalance sympathetic arousal with rest-and-digest actions.⁴¹ The sympathetic and parasympathetic systems have preganglionic neurons that originate in different parts of the CNS and postganglionic neurons that deliver impulses to target tissues. Preganglionic neurons release acetylcholine at the autonomic ganglia. The postganglionic sympathetic neurons release the primary neurotransmitters norepi-

nephrine and epinephrine, while parasympathetic neurons are cholinergic and therefore secrete acetylcholine at the target sites.

The enteric system provides local sensory and motor fibers to the gastrointestinal tract, the pancreas, and the gallbladder. This system can function autonomously but is regulated by CNS reflexes. Its control of gastrointestinal vascular tone, motility, secretions, and fluid transport plays a vital role in homeostasis. Persistent sympathetic arousal that impairs parasympathetic function and leads to disturbances of the enteric system may be related to orofacial pain because functional disorders of visceral organs controlled by the ANS seem to be common comorbid conditions.^{9,11,41}

Sympathetic input to the orofacial region. Sympathetic preganglionic neurons originate in the spinal cord. Their cell bodies are found in the intermediolateral gray matter at the level of the T12 and L1 to L3 vertebrae. They exit the spinal cord via the ventral horn at the segmental level where their cell bodies are located, but they can synapse with any of the sympathetic ganglia in the bilateral paravertebral chains. The superior portion of the sympathetic chain contains four cervical ganglia. In a rostrocaudal orientation, they are the superior cervical, middle cervical, intermediate cervical, and stellate ganglia. Postganglionic fibers leaving these sympathetic ganglia transmit motor input to the blood vessels in the head and neck, various glands, and the eyes. The skin of the face and scalp receive sympathetic innervation from the superior cervical ganglia via plexuses extending along the branches of the external carotid artery.^{34,41}

Parasympathetic input to the orofacial region. Parasympathetic preganglionic neurons originate in the brainstem nuclei, where their cell bodies are located, or in the lateral gray columns of the sacral spinal cord (S2 to S4). Cranial nerves III, VII, IX, X, and the splanchnic nerve in the pelvic region carry parasympathetic preganglionic neurons, which are considerably longer than the postganglionic

fibers because ganglia are generally located close to or embedded in the target organ.

Neurophysiology of Orofacial Pain

Orofacial pain pathways

Nociceptive impulses generated by potential or actual tissue damage are just one of the types of input that are continually assessed and evaluated throughout the various levels within the CNS. The senses (smell, sight, hearing, touch, and taste) alert the brain to stimuli through thalamic-amygdala and thalamic-cortical-amygdala circuits, and those data streams are analyzed and compared with what the brain already knows to sequence efficient behavior.^{42,43} Ongoing proprioceptive, nociceptive, thermoreceptive, baroreceptive, chemoreceptive, and vestibular inputs tell the brain how effectively its tissues are conducting responses and enables the brain to make ongoing behavioral adjustments aimed at maintaining efficiency. Nociception provides the brain an opportunity to interpret pain and make behavioral adjustments to avoid further potentially damaging stimuli.⁴⁴

First-order nociceptive nerves, whether they synapse in the spinal trigeminal nucleus or in the dorsal horn, excite the same type of second-order neurons that respond to nociceptive signals as well as a variety of sensory stimuli and are therefore called *wide-dynamic range neurons*. These neurons conduct nociception and other sensations through the brainstem and display varying degrees of arborization with structures throughout the reticular formation where baseline physiologic processes are controlled before reaching the third-order neurons in the thalamus (see Fig 1-2).^{4,45-47} Second-order neurons, stimulated by the faster-conducting A δ fibers that release glutamate, arborize less than those receiving impulses from the slower-conducting C-fibers that release a wide variety of neurotransmit-

ters.^{4,48,49} Thus, information from Aδ fibers allows for a much faster nocifensive response (ie, reflex response) than that elicited by C-fiber input, which is important in maintaining persistent pain and coordinating reparative and behavioral responses.

With sufficient temporal and/or spatial summation, third-order circuits, which start in the thalamus and connect the sensory cortex with the basal ganglia and the limbic system, interpret nociceptive input.^{1,4} This is how pain is perceived.^{1,4} Even when pain is felt, it is sometimes difficult to locate the actual source. Sites of cutaneous stimuli are easier to recognize than stimuli from the muscles and visceral organs because the dermis has more nociceptive free nerve endings than deep tissues to assess integument integrity.⁴ In response to pain interpretation, multilevel behavioral responses are coordinated, and descending motor commands are created. Whether nociception is delivered to the CNS through the spinothalamic tract or the trigeminal thalamic tract, pain perception evokes ANS-modulated cranial nerve responses.^{4,50,51} Because the tissues under cranial nerve control will continue to excite the trigeminal nociceptive pathways, an orofacial pain prognosis may be poor if ongoing pain sources beyond the trigeminal receptive fields cannot be controlled.

Nociception and pain modulation

Organisms need to be able to recognize and avoid pathologic pain to prevent potential tissue damage; however, normal daily activities should not be significantly altered by transient physiologic pain. Therefore, nociception has a biphasic effect in the CNS. Low-intensity nociceptive impulses are facilitated first through the CNS and then by stimulation of the cortex and a variety of brainstem regions, while inhibition may be facilitated via activation of the rostral ventromedial medulla and the periaqueductal gray regions.^{52,53} If nociception is relatively minor, inhibitory mechanisms will

minimize the impact of transient nociceptive barrages in the CNS that affect cognitive function and task performance. Simultaneously, low-intensity nociception via second-order neuron arborization stimulates reticular formation structures to coordinate adjustments in motor and vascular behavior.⁵¹ Because of net inhibition, such adjustments can occur almost below the level of consciousness, and efficient behavior will continue. In addition, data from human and animal studies support a role for diffuse noxious inhibitory controls (DNICs) in modulating response to painful stimuli.^{54,55} This occurs at the level of the spinal cord and is mediated when some neurons are strongly inhibited in response to a nociceptive stimulus applied to any part of the body, distinct from their excitatory receptive fields. For example, stimulation in more remote areas of the body is reported to induce inhibitory reflex movements in the jaw and tongue in response to noxious craniofacial stimulation.^{56,57} Thus, the inhibitory effects of DNIC are observed in nociceptive neurons and wide-dynamic range neurons in the spinal trigeminal nucleus as well as in sensorimotor behavioral responses involving the spinal trigeminal nucleus.^{58–61} Because the term *DNIC*, although still widely used, describes a specific inhibitory mechanism at the lower brainstem level, a group of clinicians and basic scientists has proposed a new term that could be used for psychophysical testing in humans. This new term, *conditioned pain modulation*, can be used to describe the neuronal mechanism where pain inhibits pain at all levels in the CNS.^{62,63} Importantly, dysfunction of these inhibitory control mechanisms is likely to be involved in promoting and maintaining chronic orofacial pain. Of clinical relevance, dysfunction in DNIC may make those individuals more likely to progress to a chronic pain state following tissue injury or infection in the orofacial region.

When nociception persists to excite third-order neurons and pain is realized, the brain's inhibitory capacity, *stimulation-*

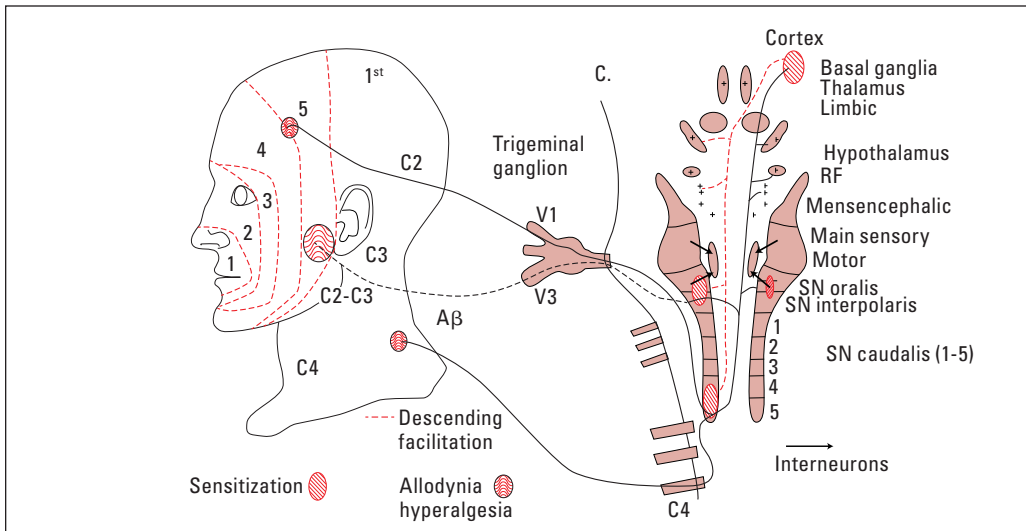


Fig 1-3 Sensitization. First-order nociceptive neurons from facial lamina 5 transmitted via V1 and C4 converge onto lamina 5 of the subnucleus caudalis. The pain sources are not controlled, summation exceeds descending inhibition, and progressive levels of central sensitization occur, first at the subnucleus caudalis and then at the ipsilateral subnucleus oralis, where A β fibers are carried on the V3 synapse. With continued summation, sensitization occurs at higher brain sites and at the contralateral subnucleus oralis. Nonpainful thermal and tactile inputs are experienced as painful (allodynia) or a more intense pain is felt (hyperalgesia) because of the effects of central sensitization. RF, reticular formation structure; SN, subnucleus.

produced analgesia (SPA), must work harder to counteract facilitation. By both noradrenergic and serotonergic pathways, SPA inhibits nociceptive transmission at many sites but initially where first- and second-order neurons synapse in the spinal trigeminal nucleus or in the dorsal horn.⁴ This descending inhibition is mediated by endogenous opioids, γ -aminobutyric acid (GABA), and various inhibitory amino acids that are located in the periaqueductal gray. These same inhibitory compounds are released when stressors induce anxiety, fear, or depression.⁶⁴ Brain circuits that interpret pain and direct descending inhibition also send signals to direct alterations in motor behavior and ANS functions. These descending commands reach structures throughout the reticular formation and, by vast pools of interneurons, affect all cranial nerve motor nuclei and alter behavior in response to pain (Fig 1-3).⁶⁵⁻⁶⁷ Al-

ternative motor pathways are recruited, and protective changes in respiration and cardiovascular mechanisms are engaged.⁶⁸ In the case of trigeminal motor activity, premotor interneurons deliver messages to the main sensory nucleus, the subnucleus oralis, and the subnucleus interpolaris, which, through interneurons, alter motor neuron sequencing in the motor nuclei. These same nuclei mediate the minor motor adjustments when net inhibition minimizes minor nociceptive volley intrusion on circuits where pain is perceived.⁴⁵⁻⁴⁷

Sensitization

With persistent nociception, excitation can exceed inhibitory capacity, and a spectrum of neuroplastic changes occurs, first peripherally and then centrally. These changes are called *peripheral* and *central sensitization*. The following changes are characteristic of neuronal

sensitization: nerve thresholds are lowered, receptive fields are enlarged, gene expression is changed, and pain is persistent and evoked by nonpainful stimuli.^{48–50} In the transition from acute to chronic pain, nociceptive neurons can change the type and level of expression of receptors and ion channels, leading to the development of a primed state.⁶⁹ In the primed state, lower levels of inflammatory mediators are required to generate nociception, and sensitizing agents can become stimulatory agents. The transformation of nociceptors to the prime state is implicated in persistent pain conditions. High-threshold peripheral nociceptors do not fire unless exposed to noxious stimuli. However, repeated stimulation can quite rapidly reduce firing thresholds by the actions of a variety of inflammatory molecules acting on various receptors. The antidromic release of neurogenic inflammatory compounds by perivascular afferents at the location of the pain also enhances peripheral nociceptor sensitization. This increase in the transmission frequency of noxious action potentials to second-order neurons is called *long-term potentiation* and, if persistent, leads to central sensitization.^{48,49}

The development of sensitization is a time- and intensity-dependent progression. Initially, low-intensity nociceptive volleys carried on A δ neurons release glutamate and activate postsynaptic α -amino-3-hydroxy-5-methyl-4-isoxazole-propionic acid (AMPA) receptors in the spinal trigeminal nucleus or dorsal horn. Higher-intensity stimuli induce C-fibers to release neuropeptides and other inflammatory mediators that cause changes in the expression and activity of neuronal receptors and ion channels that result in lower activation thresholds in second-order neurons.^{70,71}

In nonpainful states, A β fibers release only glutamate and deliver tactile sensations to the subnucleus oralis and subnucleus interpolaris or dorsal horn lamina 3 and 4. These tactile sensations are important for coordination of motor behaviors. As central sensitization develops, the thresholds where second-order

neurons arborize to the subnucleus oralis and subnucleus interpolaris are lowered, and A β fibers can begin to sprout axons into the adjacent nociceptive lamina.^{36,37,55,72} As a result of this structural reorganization in the CNS, non-painful stimuli that converge onto a sensitized CNS will be interpreted as painful (see Fig 1-3).⁷³ Reduction of inhibition and reorganization of synaptic connectivity are other mechanisms by which A β fibers may be recruited to mediate pain. Patients thus suffer allodynia (pain induced by stimuli that normally would not be perceived as painful), pain exacerbations, and hyperalgesia (an exaggerated pain response to painful stimuli).⁴

In acute pain states such as posttraumatic wounds, these mechanisms are vital to help avoid contact that would slow wound healing; survivability of the species improves as a result. However, in chronic pain states with glial cell activation augmenting CNS cytokine release, maintenance of central sensitization requires minimal nociceptive input.^{4,73,74} Understanding central sensitization is essential to pain practice because it explains light-touch pain symptoms that once were considered psychosomatic. Sensitization may also affect symptoms associated with a variety of diagnoses such as migraine, gastroesophageal reflux disease, IBS, and FM, which are often comorbid with facial pain.^{50,75,76} It is vital to abort acute pain and eliminate pain sources as quickly as possible because once central sensitization is firmly established, it becomes exceedingly difficult to diminish with current pharmacologic and nonpharmacologic therapies.

Pain in the head and face, which can be very severe and debilitating, often involves activation of the trigeminal ganglion nerves and the development of peripheral and central sensitization. The craniofacial symptoms can manifest as acute or transient conditions such as toothaches and headaches, or they can transform into more chronic conditions such as migraine, rhinosinusitis, TMDs, or trigeminal neuralgia. It is well established that peripheral

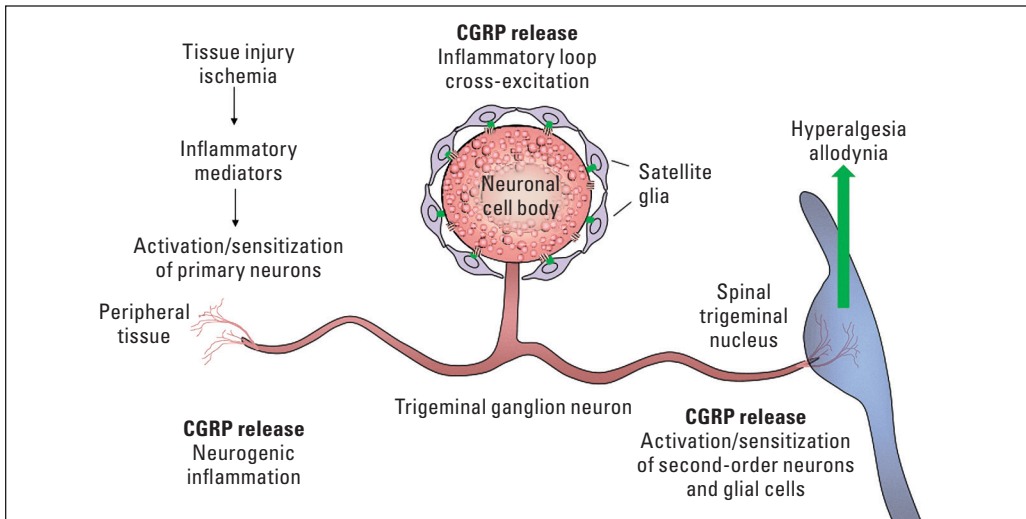


Fig 1-4 CGRP involvement in promoting peripheral and central sensitization of trigeminal nociceptive neurons. In response to tissue injury or ischemia, inflammatory mediators cause activation of primary nociceptive neurons and subsequent CGRP release (1) in peripheral tissues to promote neurogenic inflammation from the cell body in the ganglion to facilitate development of an inflammatory loop and cross-excitation, and (2) in the spinal trigeminal nucleus to cause activation of second-order neurons and glial cells, resulting in hyperalgesia and allodynia. While CGRP release in the peripheral tissue and ganglion initiate and sustain peripheral sensitization of primary trigeminal neurons, elevated CGRP levels in the upper spinal cord promote development of central sensitization via activation of astrocytes and microglia. (Reprinted with permission from Durham.⁷⁹)

tissue injury or inflammation leads to excitation of trigeminal nerves, resulting in the release of inflammatory molecules in the periphery and within the CNS at the level of the spinal trigeminal nucleus. Calcitonin gene-related peptide (CGRP), which is an abundant neuropeptide in trigeminal ganglion neurons, is implicated in the underlying pathology of diseases involving trigeminal nerve activation given its ability to promote neurogenic inflammation as well as peripheral and central sensitization (Fig 1-4).^{77–79} However, peripheral tissue injury or inflammation also leads to increased interactions between neuronal cell bodies and satellite glial cells within the trigeminal ganglion.⁸⁰ These cell-to-cell interactions, which involve the transfer of key regulatory mediators via channels or gap junctions as well as paracrine signaling, are thought to play an important role in the induction and maintenance of peripheral sensitization of trigeminal nociceptive neurons.

Under normal conditions, neuron-glia interactions in the trigeminal ganglia are involved in information processing, neuroprotection, and regulation of neuronal activity including the basal rate of spontaneous firing and threshold of activation to maintain homeostasis. While a transient increase in neuron-glia communication is associated with an acute response to inflammatory signals, stable gap junctions are formed between trigeminal neurons and satellite glia in response to sustained inflammation that is implicated in TMDs.⁸¹

Specialized glial cells found in the CNS, namely astrocytes and microglia, perform functions similar to satellite glia.⁸² Astrocytes are the most abundant type of cell found in the CNS and perform a diverse array of important functions, including regulation of neuronal development, synaptic coupling, repair, and even nutritional support. In addition, astrocytes monitor and control the concentration

of ions, neurotransmitters, and metabolites, as well as water movement, and thus play a key role in modulating the excitability state of neurons both in the brain and the spinal cord.⁸³ The other prominent glial cells in the CNS are the microglia that function as immune cells to remove cellular debris and dead cells; they also release inflammatory mediators to promote healing.^{84,85} Glial cells are responsible for regulating the extracellular environment around neurons and hence neuronal activities, and their importance in regard to the underlying pathology of many inflammatory diseases is now becoming recognized. Thus, glial cells have emerged as important cellular targets for therapeutic intervention given their role in promoting peripheral and central sensitization and persistent pain.⁸⁶

Heterotopic pain

A common phenomenon associated with orofacial pain that may confuse both patients and clinicians is heterotopic pain. When reporting chief complaints, patients often describe the site where they feel the pain, which may differ from the actual pain source.⁸⁷ For treatment to be effective, clinicians must determine the sources of pain. *Primary pain* is that which occurs at the source, as is often the case in acute injury or infection.⁸⁷ Primary pain is not a difficult problem to diagnose and treat when other pain sources are absent, but diagnostic difficulties may be presented when the source of pain is not located in the region of pain perception. Such pain is said to be *heterotopic*. In the spinal system, heterotopic pain commonly involves impulses projected along a common nerve distribution.⁸⁷ For instance, in the L4 distribution, a patient may feel pain in the big toe when the source is a hip muscle impingement or foraminal stenosis. Projected nerve pain also occurs in the trigeminal system. A good example is the pain related to trigeminal neuralgia, which is felt throughout the peripheral distribution of the affected nerve. Another diagnostic challenge is *referred pain*, in which the pain is

felt at a location served by one nerve but the source of nociception arrives at the subnucleus caudalis on a different nerve (see Fig 1-3). A common example is temple pain in the V1 distribution caused by trapezius input delivered to the subnucleus caudalis on C4.⁸⁸

The neuroanatomical basis for referred pain is provided by the convergence of multiple sensory nerves carrying input to the trigeminal spinal nuclei from cutaneous and deep tissues located throughout the head and neck. As opposed to dermatomal projected pain in the spinal system, primary nociceptive afferents from tissues served by V1, V2, V3, C2, C3, and C4 can excite some of the same second-order neurons in the spinal trigeminal nucleus. In addition, first-order nociceptive neurons carried by C5, C6, and C7 and cranial nerves VII, IX, and X can synapse in the spinal trigeminal nucleus as well as the paratrigeminal nuclei.^{4,28,29} Further, data clearly show that trigeminal second-order neurons converge on multiple brainstem locations involved in motor, ANS, and hypothalamic-pituitary-adrenal (HPA) activity.^{28,29} Convergence explains how intracranial, neck, shoulder, or throat nociception may excite the second-order neurons that receive input from facial structures. This convergence of input from tissues controlled by multiple motor nerves and delivered by multiple different sensory nerves to trigeminal nuclei helps to illustrate the important role of the trigeminal system in integrating nocifensive behaviors involving head, neck, and shoulder tissues. Because nociceptive afferents from the cervical muscles converge in the spinal trigeminal nucleus, the same location as trigeminal nociceptors, it is not surprising that cervical myofascial pain appears to be a prominent orofacial pain problem.

As important as convergence of peripheral afferents is to understanding orofacial behaviors and referred pain, it is perhaps even more significant to appreciate descending convergence from cortical, limbic, hypothalamic, and ANS regions into the vast interneuronal pools of the brainstem. These interneurons not only

reach the trigeminal motor nuclei through the spinal trigeminal nucleus; they also simultaneously convey directives to the other cranial nerve motor nuclei.^{65–67} When pain is felt, the CNS adapts, trying to minimize continued nociceptive barrages by altering patterns of movement involving the highly integrative behaviors controlled by the cranial nerves.⁵⁵ For example, the CNS restricts jaw movement in response to pain in the sternocleidomastoid, resulting in reduced jaw range of motion or cocontraction. The muscles of the jaw, tongue, face, throat, and neck work synergistically to execute multiple orofacial functions, but pain in these areas alters the movements.²⁶ Neck or shoulder pain may result in impaired jaw or neck movement just as a sore tooth alters chewing and swallowing or a severe headache compels retreat from light and sound, but these sources will also contribute to central sensitization. While convergence is the anatomical construct for referred pain, sensitization with its allodynic and hyperalgesic responses underlies the neurophysiologic changes that make it challenging to diagnose and treat persistent pain involving the trigeminal system.

The Biopsychosocial Model: Allostasis and the Emotional Motor System

Mind/body dualism is a concept that views the mind and mental phenomena as nonphysical, something apart from the body. This concept has existed since 1641, but many physicians and patients still believe that disease and pain must be the result of a detectable physical malady or injury.⁴ A mechanistic or biomedical model of medicine discounts the effects of the mind and society on disease processes. It views pain as the result of tissue damage, and if such organic disease or injury cannot be detected, then pain is explained as *psychosomatic*.

Engel⁸⁹ challenged the traditional biomedical model of disease as shortsighted in its assumptions that correcting the somatic parameters of disease defined the scope of physicians' responsibilities and that the psychosocial elements of human malfunction lie outside the responsibility and authority of medicine. After rejecting the biomedical approach that all clinicians need to do to resolve pain is to find and repair the offending tissues, Engel developed the biopsychosocial model. This model views biologic, psychologic, and sociologic issues as body systems just like the musculoskeletal or cardiovascular systems, with no separation of mind and body. Pain arises as a symptom that results from the combination of biologic, psychologic, and sociologic factors that continuously affect all individuals, and no two people experience the same spectrum of factors. Psychologic and sociologic differences are why equal degrees of nociception, a measurable biologic parameter, can produce vastly different pain and behavioral responses.

The biopsychosocial model also makes a distinction between (1) disease associated with demonstrable pathology and (2) illness in which poor health is perceived but biologic parameters do not show disease pathology. As science evolves, imaging techniques and biologic and genetic markers continue to be discovered that show the adverse effects of psychologic and sociologic issues on physiology, thus redefining disease.^{90–92} The mechanisms for central sensitization or the modification of neuroendocrine parameters that have been found to characterize abuse victims, who often suffer from many comorbid illnesses, are examples of science revealing markers for conditions previously considered as lacking biologic basis.^{93,94}

Another theory that considers chronic pain a multidimensional experience is the neuro-matrix theory put forth by Dr Melzack.⁹⁵ This novel theory of pain associated with persistent pain syndromes, which are often characterized by severe pain with little or no discernible in-

jury or pathology as well as chronic psychologic or physical stress, provides a new conceptual framework to examine orofacial pain conditions. In this model, pain is perceived in response to activation of perceptual, homeostatic, and behavioral programs after injury, pathology, or chronic stress, rather than directly only by sensory input evoked by injury, inflammation, or other pathologic events. Thus, although the neural pattern that produces pain is primarily established by genetics and modified by sensory experience, the output pattern is determined by multiple influences including neural-hormonal mechanisms of stress.

Allostasis is the adaptation of neural, neuroendocrine, and immune mechanisms in the face of stressors. *Allostatic load* refers to the physiologic changes that continued stressors produce as organisms attempt to maintain homeostasis. The changes in HPA axis function and brain cytokine activities that underlie cardiac disease and diabetes are examples of allostatic load.^{96,97} Allostasis intersects with the controversial concept known as the *emotional motor system*. The emotional motor system maintains that thoughts and emotions create neuroendocrine-mediated motor responses.^{98,99} When an organism hears, sees, or smells, its limbic system (amygdala and hippocampus) acquires primary sensory stimuli and compares their relevance with prior knowledge in a matter of 15 to 30 milliseconds to help sequence dynamic behavior.⁴² Input analysis and the emotional motor system facilitation of autonomic and cranial nerve motor behavior involve the full spectrum of brain neurochemistry and endocrine function.^{43,100}

Two scenarios not uncommon in orofacial pain practice illustrate how sociologic experience may alter supraspinal physiology and pain experience. Consider an excessively worried patient who awakes with neck pain, the same initial complaint reported by his uncle who died from cancer, or a headache patient experiencing a panic attack when a smell rekindled the fear physiology associated with an assault 7

years earlier. For these patients, investigating only acute biomedical parameters may not help and may even contribute to a deepening state of illness as the pathologic processes continue without recognition and treatment. These are patients for whom the biopsychosocial approach may prevent increased allostatic load. Taking sufficient time to obtain a thorough history and to explain the physiologic effects as they relate to psychosocial problems can help patients control factors that affect illness symptoms.

Although there is an increasing awareness of the need to assess all three systems outlined by Engel, many barriers described in a 2005 study prevent its widespread utilization.¹⁰¹ The study found that physicians and residents avoided approaching psychosocial issues because of inadequate training, lack of time, insufficient monetary incentive, and a large cultural ethos that favors “quick fixes.”¹⁰¹ The Research Diagnostic Criteria for TMDs (RDC/TMD) represent an attempt to apply both biologic (Axis I) and psychosocial (Axis II) factors to better understand a patient’s condition.^{102,103} However, the RDC/TMD have met resistance because Axis I fails to account for how referred pain and central sensitization affect physical findings, and Axis II is perceived by many as indicating that TMDs are psychosomatic despite evidence of disease. Yet, a 5-year follow-up study showed that in the 49% of TMD patients whose pain remitted, baseline psychologic measures were the same as found in the general population.¹⁰⁴ Of the remaining 51%, the 14% who experienced high pain improvement had improved psychologic parameters but minimal change in physical findings. In the 37% who did not get better, neither psychologic nor physical findings improved. Such data, which suggest that psychologic issues affect prognosis, demand that the physiology of psychosocial parameters be better addressed. Otherwise, advances in managing chronic orofacial pain problems and the conditions that may be comorbid with facial pain complaints may not be achieved.

Although a great deal of effort is dedicated to understanding genetic predisposition for disease, it is equally if not more important to realize that environmental stressors alter the expression of genetic codes and behavior. An animal model has shown that placing an identical twin in a harsher environment causes downregulation of GABA receptors and increases locus coeruleus (noradrenergic) modulated stress behaviors.¹⁰⁵ It is important to understand that each individual will interpret nociception differently, depending on the influence of cognitive processes on pain perception and allostatic adaptations in response to its lifetime experiences.

A TMD is not caused by a single gene mutation but is a result of changes in the expression of many genes that contribute to the pathology and pain characteristic of this prevalent medical condition. As documented in the OPPERA study, many of the risk factors associated with TMDs involve mechanical, chemical, or environmental stressors that increase the likelihood of developing and maintaining a chronic pathologic state.^{106,107} *Epigenetics* is an emerging area of research that focuses on understanding the impact of environmental factors on the global expression of genes and thus overall health.¹⁰⁸ Epigenetics determines how changes in one's diet; the quantity and quality of sleep; and the amount of exercise, tobacco use, and exposure to drugs and toxins influence the packaging of DNA.^{109–111} Thus, epigenetic changes ultimately control genes that can either protect from or render one more susceptible to disease progression.^{109–111}

Suffering and Pain: Comorbid Conditions

Suffering and pain are different. Though the term is notably absent in most medical dictionaries, Fordyce¹¹² defined *suffering* as the negative emotional or psychologic state that occurs in response to or in anticipation of nociception,

while *pain* was defined as perceived nociception. But suffering is not exclusive to pain, as it also characterizes sadness, sorrow, and grief. Anticipation of intense and protracted pain, sadness, or grief does affect the intensity of suffering. Moral and societal premises such as secondary gain also influence how much suffering an individual may demonstrate. Regarding sadness, time may improve some wounds. But in the case of pain from uncontrolled etiology, sensitization of the anterior cingulate cortex with limbic system and endocrine modulation may make suffering a progressive experience to the individual and those who are touched by that person's struggle.¹¹³

Acute pain, a biologic adaptive pain, is associated with quick onset and short duration. It may be very intense as in postsurgical pain, but the cause-and-effect relationship is usually apparent and the stimuli are not repeated. Central sensitization is induced only as a protective element to protect wound sites. As tissues heal, pain reduces, sensitization resolves, and duration of suffering is short.

Acute and chronic pain can be distinguished by the duration of pain; acute pain can become chronic pain if it lasts longer than 3 to 6 months, or the time it would take connective tissue to heal. *Chronic pain* is persistent pain that becomes part of the patient's daily routine. It is resistant to medical treatment because of neuroplastic changes throughout the CNS and in primary nociceptors.^{69,114} *Chronic pain* may present with psychopathology such as depression, but this is not always the case.⁴ What seems to be true in patients with chronic pain is persistent central sensitization and an increased possibility of comorbid conditions. Although conditions like conversion disorders may exist, the links between stressor effects on the CNS and the digestive, respiratory, musculoskeletal, cardiovascular, endocrine, and immune systems are redefining what used to be called *somatoform disorders*.^{91,115–118} Chronic nociception, unrelenting stressors, or horrific experiences as in posttraumatic stress disorder

der can all cause central sensitization, sympathetic upregulation, and endocrine abnormalities, which may explain why conditions such as headaches, TMDs, IBS, gastroesophageal reflux disease, and FM are so prevalent in chronic pain states.^{119–121}

The role of the clinician is changing as science clarifies how CNS dysfunction caused by uncontrolled inflammatory processes and chronic stressors leads to a maladaptive chronic pain state that affects all the major physiologic systems. The fast-paced, ever-changing nature of society unfortunately creates an environment in which people experience the fight-or-flight response multiple times on a daily basis. This lifestyle promotes a state of hyperexcitability characterized by mental exhaustion and a feeling of helplessness that favors sympathetic drive and suppresses parasympathetic function. Practitioners must see the patient's whole story, not just the portion seen through the biomedical model. For example, exposure to violence is a common experience, and in patients with chronic pain, exposure to abuse may be three-fold greater than that experienced in the general population.¹²² Patients may not always reveal these experiences given the cultural taboos associated with abuse or the repression induced by the sheer horror of the abuse or another catastrophic event. Clinicians must be aware that severe pain and comorbid conditions due to maladaptive CNS function may be the only indications of psychosocial distress. It is often a delicate subject to approach, but if pain improvement is to be achieved, clinicians must first recognize patients with problematic psychosocial histories and then refer them to skilled therapists.

A primary goal of the health care provider should be to prevent the transition from an acute episodic disease that is reversible with common pharmaceutical and behavioral treatments to a chronic pain state that is not easily altered and is often comorbid with anxiety, depression, and IBS. The risk factors for this

transition need to be evaluated and reduced. In particular, the patient should be encouraged to incorporate activities that naturally evoke a parasympathetic response such as walking, swimming, yoga, tai chi, Pilates, meditation, or mindfulness training. These exercises emphasize proper breathing and increasing flexibility, and incorporating them into the patient's daily routine will reduce the negative effect of key risk factors and help to empower the patient to become an active participant in the management of his or her disease.

Chronic Orofacial Pain Disorders: TMDs and Comorbid Conditions

The 1996 NIH Technology Assessment Conference defined a TMD as “a collection of medical and dental conditions affecting the [TMJ] and/or the muscles of mastication, as well as contiguous tissue components.”¹²³ This definition was similar to that published in the third edition of *Orofacial Pain: Guidelines for Assessment, Diagnosis, and Management* (Quintessence, 1996), which referred to contiguous tissue components as “associated structures.” It is not yet clear what constitutes *contiguous tissue components* for TMDs, and this question strongly influenced the NIH conference's major conclusions: “diagnostic classifications for TMD are flawed as they were based on signs and symptoms and not etiology; etiology was not known, no consensus on what or when to treat existed, and no therapies had proven efficacy although behavioral approaches offered the best outcomes with the least risks.” The consensus on TMD etiology and the scope of signs and symptoms has not been achieved, but research on TMDs has provided information that may help with patient care.

Many if not most patients with a TMD will recover with no or minimal care.^{16,17} A minority of TMD problems become chronic, and of those that do, one-third seemed to resolve over an 8- to 10-year period.^{124,125} TMD patients

who significantly improve may have minimal psychologic issues, while patients with chronic TMDs, like those with chronic musculoskeletal pain, have psychologic comorbidity similar to other chronic pain patients.^{104,126–129} Chronic TMD pain, like headache and most other chronic pains, is more prevalent among women, especially when multiple symptoms are present.^{130–133} It is well known that women with orofacial pain displayed more medical problems than female controls.¹¹ Over a 12-month period, 73% of adults experienced headache, 56% had back pain, 46% had stomach pain, and 27% had dental pain.^{133,134} These findings coincide with data suggesting that preexisting headache or back, abdominal, or chest pain were better predictors than depression for the onset of facial pain experienced by 12% of the population.¹³⁵ More than 81% of patients with facial pain also report pain in regions below the head.⁷⁸ TMD patients frequently have symptoms of FM, chronic fatigue syndrome, headaches, panic disorder, gastroesophageal reflux disease, IBS, multiple chemical sensitivity, posttraumatic stress disorder, and interstitial cystitis.⁹ Unfortunately, TMD patients may avoid care when symptoms carry psychosomatic stigma.¹³⁶

Heart rate variability is a measure of the beat-to-beat time interval that reflects the CNS control of the ANS tone.¹³⁷ Low heart rate variability, when the beat-to-beat time interval becomes inflexible, occurs when high sympathetic tone impedes parasympathetic (vagal) dampening of cardiac activity.¹³⁸ Low heart rate variability is a common finding for conditions such as cardiovascular disease, diabetes, depression, anxiety, cognitive problems, IBS, gastroesophageal reflux disease, posttraumatic stress disorder, migraine, FM, and sleep apnea.¹³⁹ High heart rate variability, when parasympathetic control modulates a variable beat-to-beat time interval, is associated with health and improved cognitive capacity.^{140,141}

TMD patients have been differentiated from controls by pain, anxiety, depression, sleep

disturbance, and measures of ANS reactivity, and behavioral therapies have been shown to treat these conditions more successfully than traditional dental therapies.^{142–144} Orofacial pain patients with TMDs and other comorbid conditions such as headaches, gastroesophageal reflux disease, and FM demonstrated low heart rate variability when subjected to stressors compared with controls. Three months after patients were exposed to self-regulation skills aimed at controlling stress, associated jaw, neck, and breathing behaviors and pain scores improved, and measures of heart rate variability no longer differentiated patients from pain-free controls. The improved heart rate variability scores correlated with decreased pain interference scores, suggesting enhanced self-efficacy in the face of stressors.

Patients with orofacial pain report a high degree of exposure to traumatic events and significant disability.^{120,121} In the past, disabling chronic pain was attributed to the failure of coping skills related to personality type.^{145,146} The heart rate variability study data suggest that, for some orofacial pain patients with multiple comorbid conditions, specific self-regulation skills may enable patients to cope with previously unrecognized and therefore uncontrolled physiologic disturbances associated with the pain. Acceptance of a biopsychosocial approach by the patient may largely be dependent on his or her previous psychosocial experiences.¹⁴⁷

Persistent elevation of sympathetic tone and impaired parasympathetic tone may be responsible for many comorbid conditions that affect orofacial pain patients. Heart rate variability is a noninvasive measurable parameter that may track the physiology of ANS problems in patients with trigeminal pain and shed light on its cause.¹⁴⁸ Reducing upregulated sympathetic activation, which may drive an out-of-control emotional motor system, may reduce central sensitization that underlies the refractory nature of the spectrum of conditions seen in orofacial pain practice.

Headache and orofacial pain disorders

Recurrent headache may occur in as many as 80% of TMD patients compared with a 20% to 23% occurrence rate in a general population.^{149–153} One-third of the population has been estimated to suffer from severe headache at some point in their life, a lifetime incidence similar to the 34% rate estimated for TMDs, but only 5% to 10% of North Americans have sought medical advice for severe headache.^{135,154,155} Although earlier studies have shown associations between TMDs and headache, causal interrelationships have not been demonstrated.^{131,151,156–159} However, in a study in which 61% of orofacial pain patients had headache complaints and 38% fulfilled the criteria for migraine, higher migraine disability assessment (MIDAS) scores correlated with masticatory and cervical myalgia but not with the presence or absence of intracapsular TMJ problems.¹⁶⁰ More recently, an association of sleep bruxism and painful TMDs was reported to greatly increase the risk for the development of episodic migraine, episodic tension-type headache, and especially for chronic migraine.¹⁶¹ Interestingly, in women experiencing both TMDs and migraine, the migraine condition only significantly improved when both conditions were treated. Furthermore, women suffering from migraine are likely to have more muscular and articular TMDs, which supports the notion that both disorders are clinically associated.¹⁶² This also highlights the importance of physical therapy assessment in the multidisciplinary team approach to managing complex pain patients.¹⁶²

Headaches and TMDs are major complaints associated with trigeminal pain, leading to significant suffering and absenteeism from work or school.^{134,163} Traumatic stressors may play a significant role in this suffering and pain.^{120,121} The head and neck muscles are responsible for orienting organisms to collect primary sensory input and executing orofacial behaviors. Ac-

cording to the myalgia correlation, these muscles may affect the overwhelming input that might contribute to the states of ANS dysfunction and central sensitization that characterize headache and other comorbidities.^{50,160,164–167}

Data are emerging from human genetic linkage analysis and association studies supporting the notion that mutations in genes involved in modulation of the nervous system predispose individuals to a hyperexcitable nervous system and thus play an important role in the initiation and maintenance of chronic pain.¹⁶⁸ The genes responsible for regulating neurotransmission in both the ascending and descending nociceptive pathways seem to be the ones augmented in all the chronic pain conditions examined thus far, including TMDs and migraine. For example, mutations have been identified in ion channels and receptors on neurons and glial cells that are associated with increased neuronal excitability and an enhanced sensitized state of nociceptors. Collectively, results from these studies have begun to provide a clearer understanding of how genetic variants influenced by environmental factors lead to the development of multifactorial pathologic conditions that share overlapping etiologies. There is clearly a need for more specific treatment options for the diverse array of chronic pain conditions. Findings from these genetic studies may help to direct development of more personalized strategies for managing chronic pain patients, including pharmacologic and nonpharmacologic methods. Finally, it should be noted that there are several novel therapeutic approaches that are showing efficacy in the treatment of migraine, including monoclonal antibodies that target CGRP, vagal nerve stimulation, and the use of cannabinoids.^{169–171} Given the underlying pathologic nature of orofacial pain conditions, these therapies are likely to be useful in relieving pain associated with TMDs, neuropathic pain, and other diseases involving sensitization and activation of trigeminal nociceptive neurons.

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2

General Assessment of the Orofacial Pain Patient

Key Points

- ◇ The general assessment of the orofacial pain patient is aimed at identifying the what, where, how, and why of the presenting complaint.
- ◇ Diagnosis of orofacial pain requires taking a detailed history, completing a comprehensive clinical examination, and ordering appropriate tests of established validity.
- ◇ All dental patients should be screened for temporomandibular disorders (TMDs), and positive screening findings should prompt more comprehensive evaluation.

Successful management of patients who are seeking care for orofacial pain requires the clinician to gain an understanding of the problem and establish a proper diagnosis.¹ Diagnosis (or diagnoses, as there is rarely only one) cannot be based solely on the patient's description of pain; it must also involve taking a detailed pain history, performing a comprehensive physical examination, and ordering and interpreting appropriate diagnostic tests. The orofacial pain clinician must then synthesize the information to determine pain etiology and establish a diagnosis utilizing accepted classification systems.² Familiarity with orofacial pain disorders and their classification is essential for targeted assessment and accurate diagnosis. The immediate goal after establishing the diagnosis is to initiate a treatment plan. As such, before commencing any treatment, an evaluation of the patient's overall health status, including

Box 2-1 Example of screening questions for TMDs*

- Do you have difficulty, pain, or both when opening your mouth (eg, when yawning)?
- Does your jaw get stuck, get locked, or go out?
- Do you have difficulty, pain, or both when chewing, talking, or using your jaws?
- Are you aware of noises in the jaw joints?
- Do your jaws regularly feel stiff, tight, or tired?
- Do you have pain in or near the ears, temples, or cheeks?
- Do you have frequent headaches, neck aches, or toothaches?
- Have you had a recent injury to your head, neck, or jaw?
- Have you been aware of any recent changes in your bite?
- Have you been previously treated for unexplained facial pain or a jaw joint problem?

*All dental patients should be screened for TMDs and other orofacial pain disorders. The decision to complete a comprehensive history and clinical examination will depend on the number of positive responses and the apparent severity of the problem for the patient. It should be noted that a positive response to any question may be sufficient to warrant a comprehensive examination if it is of concern to the patient or viewed as clinically significant.

their medical and surgical, drug, and psychosocial history is also required. Collaboration with various specialists (eg, otolaryngology, neurology, rheumatology, psychiatry) is often necessary. The objective of general assessment is to accurately identify the what, where, how, and why of the patient's complaint. This chapter discusses the basic tests and techniques for the assessment of an orofacial pain patient.

Screening Evaluation

It has become integral to current practice that all dental patients be screened for TMDs and other orofacial pain disorders as part of their initial and regular examinations. The results of the screening should help the clinician determine whether a more comprehensive evaluation is necessary.³ The screening may consist of a short questionnaire (Box 2-1), a brief history, and a limited examination. Although the value of questionnaires may be challenged, a questionnaire can facilitate the clinical examination by focusing on specific complaints.⁴ The TMD screener is a three-item questionnaire including questions about duration and timing of

pain and aggravating and relieving factors. The questionnaire has a sensitivity of 98% and a specificity of 97% and has been shown to both accurately identify painful TMDs and to discriminate them from other conditions that present with overlapping symptoms.⁵ The high positive predictive value (over 98) suggests that the TMD screener can be used to identify patients requiring a more comprehensive evaluation.

The TMD screening examination usually consists of observation of the mandibular range of motion, palpation of the temporomandibular joints (TMJs), and palpation of the masseter and temporalis muscles for pain or tenderness (Box 2-2). Palpation and/or auscultation of the joints for sounds and observation of jaw function can disclose uncoordinated movements that may indicate internal biomechanical problems.⁶ Caution should be observed when evaluating the results of the screening process because the clinical findings and the patient's complaints may not be consistent. Positive findings on the screening evaluation may prompt a more comprehensive evaluation. An understanding of the clinical significance of positive findings is essential. For example, a clinical sign such

Box 2-2 Example of screening examination procedure for TMDs*

1. Measure range of motion of the mandible on opening and right and left lateral movements. (Note any incoordination, deflection, or deviation in the movements.)
2. Palpate for preauricular or intrameatal TMJ tenderness.
3. Auscultate and/or palpate for TMJ sounds (ie, clicking or crepitation).
4. Palpate for tenderness and radiating trigger points in the masseter, temporalis, and cervical muscles.
5. Note excessive occlusal wear, excessive tooth mobility, buccal mucosal ridging, or lateral tongue scalloping.
6. Inspect symmetry and alignment of the face, jaws, and dental arches.

*All dental patients should be screened for TMDs and other orofacial pains using this or a similar cursory clinical examination. The need for a comprehensive history and clinical examination will depend on the number of positive findings and the clinical significance of each finding. Any single positive finding may be sufficient to warrant a comprehensive examination.

as a clicking TMJ may merely represent a stable, nonpainful condition that does not require treatment.

Comprehensive Evaluation

A comprehensive evaluation should be performed when a patient's complaints of pain are not of dental origin or when a patient's screening evaluation results are positive for an orofacial pain disorder. A comprehensive evaluation starts with a detailed history (Box 2-3). The examination process that follows may include some or all of the components listed in Table 2-1. Many patients present with a list of complaints; if the clinician carefully analyzes the

components of each complaint, this can lead to a differential diagnosis. A meticulous history will often guide the clinician to the most likely diagnoses and therefore aid in determining what additional diagnostic procedures may be appropriate, if any.

History Taking

The interview, or history, is usually the first contact between the clinician and the patient, and as such, an empathetic attitude by the clinician can quickly create a bond critical to successful communication.

Chief complaints

The patient must be allowed to comfortably express the symptoms that prompted the consultation, although the clinician must take control of the interview to gather information in an organized manner. Adequate time is necessary to allow the patient to fully describe each of the complaints. The complaints are documented in the order of severity as indicated by the patient, and details of each complaint are elicited in a systematic manner.

History of chief complaints

A description of each chief complaint usually includes its location, onset, quality, intensity, frequency and duration; triggering, exacerbating and alleviating factors; and associated symptoms. The combination of these features often represents recognizable patterns that can help the clinician to appropriately categorize the complaint, resulting in well-directed interventions.

Location. Very often, the patient will complain of pain in a part of the face or head in terms consistent with how he or she may understand the anatomy. Therefore, it is helpful to have the patient identify the exact location of the pain using a finger to either point to or cir-

Box 2-3 Comprehensive history format for orofacial pain patients***1. Chief complaint(s) and history of present illness**

- Date and event of onset
- Location
- Quality
- Intensity
- Duration
- Frequency
- Remissions or change over time
- Modifying factors (alleviating, precipitating, or aggravating)
- Previous treatment results

2. Medical history

- Current or preexisting relevant physical disorders or disease (specifically, systemic arthritides or other musculoskeletal or rheumatologic conditions)
- Sleep disorders and sleep-related breathing disorders
- Previous treatments, surgeries, and/or hospitalizations

- Trauma to the head and face
- Medications (prescription and nonprescription)
- Allergies to medications
- Alcohol and other substances of abuse

3. Dental history

- Current or preexisting relevant physical disorders or diseases
- Previous treatments, including the patient's attitude toward treatment
- History of trauma to the head and neck (including iatrogenic trauma)
- Parafunctional history, both awake and asleep

4. Psychosocial history

- Social, behavioral, and psychologic issues
- Occupational, recreational, and family status
- Litigation, disability, or secondary gain issues

*All dental patients should be screened for TMDs and other orofacial pain disorders. The decision to complete a comprehensive history and clinical examination will depend on the number of positive responses and the apparent severity of the problem for the patient. It should be noted that a positive response to any question may be sufficient to warrant a comprehensive examination if it is of concern to the patient or viewed as clinically significant.

Table 2-1 Comprehensive orofacial pain physical examination procedures

| Type of evaluation | Reviewing sequence |
|----------------------------------|---|
| General head and neck | 1. Note scars; asymmetry; unusual size, shape, consistency, or posture; and involuntary movement or tenderness. |
| Muscles, TMJ, and cervical spine | 1. Palpate the muscles of mastication and cervical muscles. 2. Palpate the TMJ preauricular. 3. Palpate cervical vertebrae. 4. Measure range of motion and its association with pain. 5. Auscultate and palpate for joint noises in all movements. 6. Guide mandibular movement, noting pain, end feel, and joint noise. 7. Note any tenderness, swelling, enlargement, or unusual texture. |
| Neurologic | 1. Perform cranial nerve screening and note signs and symptoms. 2. Note vascular compression of the temporal and carotid arteries. |
| Ear, nose, and throat | 1. Inspect the ears and nose. 2. Inspect the oropharynx and uvula (Mallampati score, tonsillar hypertrophy grade). |
| Intraoral | 1. Assess hard and soft tissue conditions or disease. |

Table 2-2 Pain-quality descriptors and secondary symptoms associated with different pain categories

| Pain category | Quality | Secondary symptoms |
|-----------------|---|---|
| Musculoskeletal | <ul style="list-style-type: none"> • Dull • Aching • Pressure • Depressing • Tight • Stiff • Occasionally sharp | <ul style="list-style-type: none"> • Flushing • Hyperalgesia • Allodynia • Can refer to or be referred from distant sites • Worse with function |
| Neurovascular | <ul style="list-style-type: none"> • Throbbing • Stabbing • Pounding • Rhythmic | <ul style="list-style-type: none"> • Worsened by increasing intracranial pressure (eg, Valsalva, bending over, physical activity) • Sensitivity to light and/or sound • Nausea, vomiting |
| Neuropathic | <ul style="list-style-type: none"> • Shooting • Bright • Stimulating • Burning • Itchy • Electric shock–like • Cutting | <ul style="list-style-type: none"> • Numbness • Hyperalgesia • Paresthesia • Allodynia • Dysesthesia |
| Psychogenic | <ul style="list-style-type: none"> • Descriptive | <ul style="list-style-type: none"> • Complaint patterns often do not match anatomical sensory supply |

cumscribe the area of complaint. An important concept to keep in mind is that the location or site of the pain does not always correspond to the source of the pain. Therefore, finding the true source of pain is imperative for both a diagnosis and effective treatment. To assess the extent of pain, asking the patient to draw his or her pain(s) on a whole body mannequin may be useful.

Onset. It is important to understand the circumstances that precipitated the pain, if any. Trauma is a frequent cause of pain and should be differentiated from pain secondary to systemic disease or personal stressors. It is also important to know how the pain begins with each episode (ie, whether it arises gradually or suddenly or is spontaneous). The temporal component of pain, be it the time of day, week, or month the pain occurs may also render important clues regarding diagnosis, contributing factors, and treatment.

Quality. Different diagnostic categories of pain may be distinguished based on the quality of pain (Table 2-2). However, the clinician must be cautious when categorizing pain quality because pain related to certain musculoskeletal disorders can mimic neurovascular or neuropathic disorders, and the reverse may also be true. Several clinically validated screening tools with high sensitivity and specificity, although not specifically designed for orofacial pain, are available to help clinicians distinguish between neuropathic pain, nociceptive pain, and mixed pain.^{7,8} They include the Leeds Assessment of Neuropathic Symptoms and Signs (LANSS) and S-LANSS (short version), Douleur Neuropathique (DN4), Neuropathic Pain Questionnaire (NPQ), PainDETECT, and ID-Pain.^{9–14} The LANSS and DN4 contain clinical items in addition to self-reported symptoms. The self-report items of the DN4 can be used alone with good sensitivity and specificity.¹¹

Intensity. The intensity of pain is subjective, variable, and often influenced by the psychosocial status of the patient. It is important for clinicians to understand the patient's interpretation of the intensity of his or her pain so that treatment priorities can be established. The intensity of the pain can be rated on a verbal rating scale (ie, mild, moderate, or severe); numeric rating scale (ie, a number between 0 and 10, where 0 represents "no pain" and 10 represents the "most extreme pain"); or a visual analog scale (ie, a 10-cm line labeled at one end with "no pain" and at the other end with "most extreme pain"). Because intensity can vary, it may be rated at the time of presentation in addition to the intensity at worst, best, and average in the preceding week. Sensory changes such as diminished or increased perception of touch or pain can be similarly rated and may relate to neuropathic disorders or centrally mediated pain disorders.

Frequency and duration. The frequency of painful episodes yields information such as whether the pain comes in clusters, has periods of remission, or is constant. The duration of pain may be recorded in seconds, minutes, hours, days, weeks, or months. The daily duration of pain is rated as continuous or intermittent. If intermittent, the pain can be rated as brief, momentary, or persisting for minutes or hours. The frequency and duration of periods of remission should also be recorded.

Modulating factors. Precipitating, aggravating, and alleviating factors yield important information. Seemingly minor details that may not strike the patient as important may have tremendous diagnostic value. Examples include *precipitating factors* such as light wind, touch, or shaving initiating the pain and *aggravating factors* such as having increased pain during periods of personal stressors. Similarly, discovering that jaw function does not precipitate or aggravate an individual's pain is of equivalent diagnostic importance. In an

injured musculoskeletal system, symptoms tend to aggravate when the system is used. If the masticatory system is the source of pain, then pain should worsen during jaw function. If it does not worsen, the source of the pain may be outside of the masticatory system.

Associated symptoms. Very often, a symptom associated with the patient's pain complaint can help the clinician narrow his or her diagnostic focus. Sensory and motor changes as well as autonomic features may be recorded. For example, the presence of visual and sensory changes or light or sound sensitivity may be indicative of migraine with aura, whereas drooping, redness, and/or tearing of the eye may indicate a trigeminal autonomic cephalgia.

Previous treatments

Prior medical and dental interventions for each complaint should be listed, along with the patient's perception of results. Results of prior treatment can offer insight into the nature of the complaint. For instance, if an anti-inflammatory drug alleviates the pain complaint, the pain is likely not of neuropathic origin. The patient's recall of medications, dosages, and length of medication trials should also be recorded. This information helps the clinician to evaluate whether previous therapies have been adequately tried and titrated or if they were discontinued due to side effects or adverse events. This part of the interview may also provide insight into patient compliance with previously proposed therapies.

Medical and dental history

Past illnesses, surgeries, developmental or genetic abnormalities, and any sequelae should be documented. Long- and short-term use of medications (including over-the-counter medications and herbal, vitamin, and mineral preparations) and their purpose should also be documented, as they may influence potential

treatment options. Use of caffeine, tobacco, alcohol, and recreational drugs should be noted, as well as past or present substance abuse. The patient should be questioned about trauma, both physical and emotional. A complete dental history should be obtained, particularly as it relates to the chief complaint, or as the patient believes it relates to the chief complaint. Complications of therapies are important to document, as are any behaviors such as clenching (while awake or during sleep), bruxism, and other parafunctional activities (eg, gum chewing, nail biting). Because the patient's complaints may be a manifestation of systemic disease, he or she should be questioned regarding any symptoms that might relate to systemic disorders, such as those affecting connective tissue, autoimmune disorders, thyroid or salivary glands, fibromyalgia, diabetes, cardiac disorders, or Lyme disease, as this may influence treatment options and/or prognosis.

Patients must also be questioned about sleep habits and sleep disruptions. Orofacial pain is often associated with frequent awakenings or inadequate sleep duration. Sleep disorders may exist as a medical comorbidity or may be directly caused by pain.² Pain can disrupt sleep, and sleep loss can increase pain sensation.¹⁵ The orofacial pain clinician must be knowledgeable about normal sleep structure and function and how pain or stressors may disrupt sleep.² Psychometric instruments such as the Pittsburgh Sleep Quality Index are useful to assess sleep quality.¹⁶ The Epworth Sleepiness Scale is useful in assessing daytime sleepiness.^{17,18} The relationship of pain patterns to the sleep/wake cycle as well as risk factors for sleep-related breathing disorders such as obstructive sleep apnea and sleep-related bruxism should be assessed.¹⁹ The STOP questionnaire, the STOP-Bang questionnaire, the Berlin questionnaire, and the multivariable apnea prediction index (MAPI) are useful tools to assess for obstructive sleep apnea.²⁰⁻²² Patients with a suspected sleep disorder should be referred to a sleep physi-

cian for full evaluation and diagnosis. The diagnosis of a sleep disorder, including obstructive sleep apnea and other sleep-related breathing disorders, must be made by a physician.²³ The orofacial pain clinician can work with the sleep physician in the management of a patient with obstructive sleep apnea (see chapter 11).

Psychosocial history

For some patients, psychologic and behavioral issues may result in orofacial pain. For others, these problems may be the primary etiologic factor or may play a role in sustaining or amplifying the pain. Therefore, it is advised that the history-gathering portion of the comprehensive evaluation include an evaluation of behavioral, social, emotional, and cognitive factors that can possibly initiate, sustain, or result from the patient's pain complaints (Box 2-4). The psychosocial history may provide insight into the patient's mental status and coping skills, interactions with others, and the presence of any psychologic overlay.

An evaluation for the presence of stressors and the patient's response to stress is important to the diagnostic process. Specific inquiries should be directed to disclose a history of traumatic life events, such as sexual abuse or domestic violence. Litigation, the expectation of monetary reward for disability, or secondary gain can also be complicating factors for the patient's prognosis. It needs to be determined if the patient has depression, anxiety, or both, because these are often comorbid and complicating factors related to chronic pain. A brief screening tool to assess anxiety and depression is the four-item Patient Health Questionnaire (PHQ-4).²⁴ A more elaborate questionnaire to evaluate anxiety and depression, among other disorders, is the 90-item Symptom Check List Revised (SCL-90-R).²⁵ In depressed patients, it is especially important to assess and document the risk of suicidal ideation and understand that suicide risk may fluctuate, for example, with increased life stressors.²⁶

An appreciation of how pain affects the patient's life can help direct treatment. The Graded Chronic Pain Scale (GCPS) is a brief questionnaire that may be helpful to assess the patient's pain intensity and how the pain interferes with his or her life (see chapter 12 for more details on psychologic disorders, psychometric questionnaires, and suicidal ideation).²⁷ Referral is recommended when significant factors are identified.

Physical Examination

Vital signs

Baseline blood pressure and pulse rate are recorded, and other vital signs (eg, respiration rate, temperature, height, and weight) may be obtained. Evaluating and recording baseline vital signs may provide valuable information for medically compromised patients and patients taking medications. Abnormal findings should prompt a more thorough evaluation with possible referral to a physician.

Neurologic screening

Orofacial pain complaints may be the result of a neurologic problem. As part of the orofacial pain examination, a cranial nerve screening is performed, aimed at assessing the function (ie, strength, sensation) of the nerves on the right and left sides. Cranial nerve dysfunction may manifest as changes in either motor or sensory function. Abnormal movement of muscles stimulated by one of the cranial nerves can indicate pathosis along the motor pathways. A patient reporting sensory alterations may be tested for anesthesia, paresthesia, dysesthesia, allodynia, and hyperalgesia. Topical and local anesthetic blocking may be part of the neurologic screening. Areas of altered sensation can be mapped at regular intervals, which may help to determine if the patient's condition is progressive or if treatment

Box 2-4 Checklist of psychologic and behavioral factors

- Inconsistent, inappropriate, and/or vague reports of pain
- Symptoms incompatible with the innervation and function of anatomical structures
- Overdramatization of symptoms
- Symptoms that vary with life events
- Significant pain of greater than 6 months' duration
- Repeated failures with conventional therapies
- Inconsistent response to medications
- History of other stress-related disorders
- Major life events (eg, new job, marriage, divorce, death of a family member or friend)
- Evidence of alcohol and drug abuse
- Clinically significant anxiety, depression, or suicidal or homicidal ideation
- Evidence of secondary gain

is effective. However, altered sensations are not pathognomonic for neuropathic pain.

Table 2-3 lists the cranial nerves and the most common methods of screening these nerves for dysfunction. Abnormal findings should prompt a more detailed neurologic evaluation, and if indicated, the patient should be referred to an appropriate medical specialist. Other texts are recommended for a complete review of the components of a neurologic and cranial nerve examination.

General inspection

General inspection of the head and neck includes recording of overall appearance; masses and/or asymmetry of the face, jaws, neck, and thyroid; presence of scars, unusual or abnormal posture, and involuntary move-

Table 2-3 Overview of cranial nerves and tests to evaluate their functions

| No. | Cranial nerve | Test |
|------|----------------------------|---|
| I | Olfactory | Sense of smell, tested with camphor, coffee, and vanilla |
| II | Optic | Visual acuity/visual field: pupillary light reflex |
| III | Oculomotor | Pupillary light reflexes/accommodation, eyelid elevation, most eye movements |
| IV | Trochlear | Downward gaze during adduction |
| V | Trigeminal | Sensation of light touch to face in all three divisions; motor innervation of muscles of mastication (strength); corneal reflex |
| VI | Abducens | Lateral gaze (III, IV, and VI); tested by having the patient follow finger in an H pattern) |
| VII | Facial | Facial expressions; corneal reflex; taste to the anterior two-thirds of the tongue |
| VIII | Acoustic vestibulocochlear | Hearing (eg, ability to hear a watch tick); Weber and Rinne tests (tuning fork); observation for nystagmus on extraocular muscle testing; caloric testing |
| IX | Glossopharyngeal | Gag reflex; taste to posterior one-third of the tongue |
| X | Vagus | Speech; palatal/uvular elevation; gag reflex |
| XI | Accessory | Function of sternocleidomastoid and trapezius muscles (press against resistance) |
| XII | Hypoglossal | Tongue bulk, strength, and movement (protrude and wiggle, press against resistance) |

ments; and respiration and breathing pattern. It may also be important to observe the overall gait of the individual. This can easily be done when the patient is entering or exiting the examination area.

Palpation

Muscles

The muscles of mastication are palpated in an attempt to reproduce familiar pain or identify tenderness upon palpation and to elicit referral patterns. *Familiar pain* is pain that is described by the patient as being similar to their experienced pain.²⁸ Reproducing the familiar pain helps to differentiate it from incidental pain provoked by muscle palpation.

The clinician may also palpate for *myofascial trigger points*, which are hyperirritable sites in taut bands of muscle and tendons that, when

palpated, cause discomfort and may radiate or refer pain.^{29,30} The temporalis, deep and superficial masseter, medial pterygoid, and suprahyoid muscles are often examined. Familiar pain may also be reproduced by asking the patient to clench the teeth while the clinician palpates the patient's masticatory muscles. The inferior lateral pterygoid muscle is difficult to palpate intraorally but can be evaluated by functional manipulation, by challenging the muscle to contract against resistance, or by observing symptom changes from stretching.^{31–34} Myalgia may be exacerbated during this maneuver. Similar procedures of functional manipulation may be used for the superior lateral pterygoid and medial pterygoid muscles.³³ Muscles and structures that can be palpated with an intraoral approach include the medial pterygoid muscle, anterior digastric muscle, and the temporal tendon.

It is common for orofacial pain complaints to be caused by, and referred from, primary pain sites among the cervical structures.³⁴ Therefore, evaluation of the cervical range of motion and palpation of the cervical muscles, including the sternocleidomastoid, splenius capitis, trapezius, levator scapulae, and scalenes should be performed as part of the comprehensive orofacial pain evaluation. The recommended pressure when palpating head and neck muscles is between 0.5 and 4 kg/cm², maintained for about 5 to 20 seconds, although there is no universally accepted reference standard for the diagnosis of trigger points.^{35–37}

Joints

The TMJs (lateral capsules) are palpated bilaterally for tenderness, pain, swelling, and patterns of movement. Palpation and/or stethoscope auscultation during jaw movements is a common method of detecting joint sounds. The presence and timing of early, middle, or late opening and/or closing sounds or noises (eg, clicking, popping, crepitus) and other interferences with smooth jaw movement should be noted.³⁸ Joint sounds can be signs of an intra-capsular abnormality, such as internal derangement, degenerative processes, or architectural defects of articulating surfaces. They may correlate with pain or pathologic conditions or may be due to functional adaptations not associated with pain or dysfunction. Joint sounds are common in the general population and should be evaluated within the context of other presenting signs and symptoms.³⁹ While the predictive value of joint palpation is low in nonpatient populations, positive findings may have clinical significance in symptomatic patients.^{40–42}

Lymph nodes

As part of the head and neck examination, the clinician should palpate lymph nodes, including the submental, submandibular, superficial, and deep cervical chains. The latter group may be examined with relative ease by palpating the relaxed sternocleidomastoid muscle.

Disease states of the oral cavity are most often reflected in changes of submental and submandibular lymph nodes.³⁸ Lymph nodes in a healthy individual are soft, nonpalpable structures. Lymph nodes that are palpable, swollen, hard, painful, fixed, or nodular are considered abnormal and potentially indicative of infection, inflammation, or neoplasm. The cause of abnormal nodes requires further investigation.⁴³

Arteries

The temporal arteries may be palpated for tenderness, consistency, and provocation of pain in patients over the age of 50 years who complain of headache. Pain on palpation of the temporal artery may be a sign of giant cell arteritis, particularly in elderly patients (see chapter 4). If giant cell arteritis is suspected, additional diagnostic tests are indicated in addition to immediate physician referral.

Range of movement

The recording of mandibular range of movement in opening, lateral, and protrusive excursions with a millimeter ruler is a core examination procedure for TMDs, and the recorded measurements may also serve as a treatment outcome measure. Normal mandibular opening ranges between 40 and 55 mm, whereas excursive movements of at least 7 mm are considered normal.⁴⁴ While these are the generally accepted ranges, individual measurements may vary depending on many factors such as stature, craniofacial form, and other variables.^{45,46} The normal opening range or active range of motion is less in women than in men and decreases with increasing age.⁴⁶ An international collaborative effort of experts has led to scientifically validated and reliable examination protocols and diagnostic criteria for the most common TMDs. The Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) have been published and are highly recommended in both the clinical and research settings.²⁸

Three interincisal mouth opening measurements may be utilized to obtain important information: maximum pain-free opening; maximum unassisted opening; and maximum assisted opening. *Maximal pain-free opening* is that which can be attained without pain. *Maximum unassisted mouth opening*, also called *active range of motion*, is the mouth opening measurement that can be achieved by the patient regardless of the presence of pain. *Assisted mouth opening*, also called *passive range of motion*, is defined as the maximal mouth opening that can be attained with gentle stretching by the examiner after the patient has reached maximum unassisted mouth opening. The “jaw opening pattern” should be noted as either a straight line or deviated to the right, left, or both sides. A *corrected deviation* means that the mandible deviates away from the midline at first but then returns to the midline, while an *uncorrected deviation* means the mandible does not return to the midline. The mandibular lateral and protrusive range of motion should also be measured and recorded as outlined in the DC/TMD.²⁸ The location and severity of familiar pain elicited by these movements should be recorded. It is important to engage the patient’s perception of restricted movement or reduced quality of movement.⁴⁶

Cervical range of movement may also be recorded and includes rotation to the left and right (normal range of motion, 65 to 75 degrees), lateral tilt (normal range of motion, 35 to 45 degrees), flexion (normal range of motion, 50 to 60 degrees), and extension (normal range of motion, 60 to 70 degrees). These normal ranges are for middle-aged individuals. The range of motion declines approximately 5 degrees for extension and 3 degrees for all other movements as one ages based upon a 10-year period.⁴⁷

Ear, nose, and throat

Patients who present for assessment of orofacial pain may be suffering from diseases or

disorders of the ear, nose, and throat. Given the close and complex anatomical and functional relationship of these structures to the orofacial structures, otolaryngologic problems should be considered as potential causes of orofacial pain and dysfunction. For example, it is common for patients to report ear pain (otalgia) when the pain is primarily due to a TMD. Maxillary tooth pain can be caused by maxillary sinus disease and vice versa. Although aural symptoms are very common in TMD patients, particularly ear fullness and otalgia, symptoms such as ear discharge, hearing loss, tinnitus, dysequilibrium, and vertigo should raise suspicion of possible otologic causes of orofacial pain that require further investigation.^{48,49} To date, the cause and background of aural symptoms associated with TMD is not fully understood, and no cause-effect relationship has been identified.^{50,51}

In a systematic review inquiring about the effectiveness of conservative TMD therapies on changes to otologic signs and symptoms in adult patients with a TMD and related otologic complaints, the authors concluded there to be insufficient evidence for or against the employment of these interventions. Furthermore, it was suggested that further studies with a higher level of evidence and more representative samples should be conducted to increase our understanding regarding the effect of TMD therapy on otologic complaints.⁵²

Examination of the external ear, the external auditory canal, and the tympanic membrane is performed using an otoscope.⁵³ The outer ear may be examined for redness or swelling, which could indicate an infection or inflammatory process. The external auditory canal may be examined by pulling the ear upward and backward to straighten the canal for inspection. The canal is then observed for signs of infection, inflammation, discharge, or blockage. The properly trained clinician can observe the tympanic membrane (ie, eardrum) for any gross pathology that could explain the complaint of ear pain. If the clinician has

concerns, then referral to an otolaryngologist would be warranted.

When evaluating the nose and sinuses, the skin overlying the nose and maxilla is first inspected for abnormalities, such as unexplained ulcers, dark moles, or tissue growths. The skin over the maxillary and frontal sinuses is palpated and tenderness noted. The trained clinician may inspect the nostrils using adequate light and a nasal speculum, looking for swollen turbinates and deviated septa that may be associated with breathing problems.

All major salivary glands, including the parotid, submandibular, and sublingual glands may be palpated. Salivary gland duct exits can be inspected intraorally to confirm salivary flow. If no spontaneous flow is observed after the area of the exit is dried, the gland can be massaged, with the clinician noting color and consistency of any discharged fluid, if any. When indicated, a salivary flow test can be performed, and the saliva may be cultured.⁵⁴

The oropharynx is readily visualized by retraction of the tongue with a tongue depressor or dental mirror. The tonsils and posterior pharyngeal walls should be visualized. Airway patency can be visualized and scored via the modified Mallampati or the Standardized Tonsillar Hypertrophy scales.^{55,56}

Dental examination

Depending on the history, the patient may be provided with either a screening or a more thorough dental examination. Particularly where dental or oral mucosal pathosis is suspected as the source of orofacial pain, clinical examination of the oral hard and soft tissues is indicated, possibly in conjunction with radiography. It should always be remembered that the vast majority of orofacial pain is of odontogenic origin or related to the associated structures. Assessment for possible odontogenic pain requires careful inspection for dental caries, cracked teeth, and use of pulp vitality testing procedures. In addition to pulp vital-

ity testing, the presence of periapical inflammation can be assessed via tooth percussion and mobility testing, periodontal probing, and periapical radiography. Transillumination may be of assistance in detecting the presence of cracked teeth.

Soft tissue or superficial pain may be caused by trauma, oral mucosal infections and disease, and neoplasia. The tongue, floor of the mouth, palate (hard and soft), gingival tissue, and buccal mucosa should be carefully inspected and palpated. The presence of oral ulceration, inflammation, infections, and soft tissue ridging should be noted. Diagnostic anesthesia, either topical and/or local, may assist in the diagnostic process of both odontogenic and soft tissue orofacial pain.

The dental occlusion should be evaluated, when indicated, keeping in mind that occlusal variables are of limited use in the diagnosis of TMDs and may be the result of a TMD process rather than its cause.^{57,58} A number of occlusal variables have been associated with the presence of various TMDs.⁵⁹ Accordingly, extensive tooth wear patterns, anterior open bites, unilateral crossbites, and large slides between the jaw's retruded and maximum intercuspation positions should be recorded. These baseline studies may be of importance in monitoring a progressive disease process.

Diagnostic Tests

The gold standard for diagnosis of orofacial pain, including TMDs, is a thorough history, examination (Axis I), psychosocial assessment (Axis II), and appropriate imaging, when necessary.⁶⁰ The clinical diagnostic criteria and examination protocol for the most common TMDs can be obtained via the DC/TMD, which is readily accessible on the website of the International Network for Orofacial Pain and Related Disorders Methodology (INFORM; previously known as the International RDC/TMD Consortium Network). Standardized and

validated psychometric tools for assessment of the patient's psychosocial characteristics (Axis II) are also available. Adjunctive diagnostic tests are not necessary in every case; however, there are tests and procedures that may contribute significantly to the diagnostic process for the individual patient. A test should be performed only if it is deemed appropriate for the individual patient to either confirm or rule out a diagnosis and therefore potentially alter the treatment that is being considered.

A selected diagnostic test should have established scientific merit. Reliability and validity are measures that reflect how well a diagnostic test or procedure can measure what it purports to assess. For such a test or procedure to become clinically useful, it must first be proven to consistently, accurately, and reliably identify or measure the specific target. *Reliability* refers to the stability and consistency of measurements, whereas *validity* refers to the test's ability to measure what it is supposed to measure. Additionally, if whatever is measured has no established diagnostic value, then the diagnostic test cannot be considered valid. Several other factors are important in determining the usefulness of certain instruments proposed for use in diagnosis. These include the sensitivity, specificity, and positive and negative predictive values. *Sensitivity* is a measure of how well a certain test is able to identify a disease when the disease is actually present, also called the *true positive rate*. If a highly sensitive test is negative, it rules out the disease. *Specificity* is a measure of how well a test, when negative, identifies those who do not have the disorder, also called the *true negative rate*. A test with high specificity, when positive, can rule in the disease. For appropriate diagnosis, both sensitivity and specificity of the test should be over 70%. The *positive predictive value* is a measure of the probability that a person has the disease, given a positive result. Likewise, the *negative predictive value* is the probability that a person does not have the disease, given a negative result. Many

instruments meet the criteria for validity and reliability but demonstrate low sensitivity and specificity and therefore should not be used to establish a diagnosis.^{61–69} Relying on these instruments as diagnostic aids could lead to overtreatment and unnecessary increased medical costs.

The lack of scientific validation of many diagnostic tests, especially use of certain technologic devices, may lead to many false positive diagnoses and some false negative diagnoses. Some of these devices are discussed in the next section. There are immediate and implied future health and financial costs related to treating false positives and delayed costs of not treating false negatives. Until well-controlled, double-blind clinical trials are performed on specific subgroups of orofacial pain patients and are compared with control groups, these tests should be considered experimental and should not be used in routine clinical practice.

Electrodiagnostic testing

There are many electronic devices on the market that claim to aid in the diagnosis and treatment of TMDs. Although many of these devices may have the potential to be clinically useful, their reliability, validity, safety, and efficacy have yet to be established.^{62,65–69}

Jaw-tracking devices

Observing and recording the range, direction, and quality of various jaw movements is an important aspect of assessing TMDs. Jaw-tracking devices allow jaw movements to be visualized and recorded; however, the utility of these tracings for diagnostic purposes is still unclear.^{69–74} Mandibular movement measurements may be obtained by use of jaw-tracking devices; however, there are no data to demonstrate that this technique is any more useful in measuring mandibular movements than a traditional millimeter ruler.⁶² With this in mind, cost efficiency should be considered, and routine use of these

devices for TMD diagnosis is currently not supported by the scientific literature.⁶²

Although these devices are cleared by the US Food and Drug Administration from a safety standpoint, a special notation was added that documentation for efficacy in diagnosis has to be provided for each device.^{60,62} The usefulness of kinesiographic recordings of jaw movements to diagnose TMJ articular disc displacements compared with the use of the gold standard (ie, magnetic resonance imaging [MRI]) has been investigated. The specificity and positive predictive values for all kinesiograph variables were found to be well below acceptable standards to recommend its use.⁷⁵ Furthermore, the use of these devices in the diagnosis of myofascial pain as either a stand-alone measurement or an adjunct to clinical decisions fails to meet the standards of reliability and validity for their usage.⁷⁶ A review of literature published since the last edition of the *AAOP Guidelines* failed to identify new articles supporting the use of jaw tracking as a diagnostic aid in TMDs. Therefore, at this time, jaw-tracking devices are not recommended as part of the orofacial pain evaluation.⁶²

Electromyography

Electromyography (EMG) is a useful tool in measuring muscle activity and nerve conduction and has been shown to be reliable.^{74–80} Although numerous publications have documented the use of EMG testing to establish diagnoses of TMDs, a thorough review of the evidence-based literature concluded that limitations with regard to reliability, validity, sensitivity, and specificity render EMG testing of limited value for TMD diagnosis.^{62–69,76,81–83} Furthermore, increased EMG activity correlates poorly with masticatory muscle pain, and it is more likely that long-lasting, low-level contractions may be more relevant.^{84–86} A study investigating the diagnostic accuracy of surface EMG for myofascial pain concluded that EMG should not be used clinically to diagnose or monitor the course of TMDs in an individual

patient because of the potential risk for overdiagnosis and/or overtreatment.⁷⁸ Similar conclusions as to the lack of utility on the use of EMG in diagnosing TMDs have also been described in several systematic reviews.^{85,86}

Thermography

The use of thermography to diagnose painful neurologic and musculoskeletal conditions is based on the presence of thermal asymmetries of the skin when comparing normal and abnormal sites. Thermographic assessments of TMDs and other orofacial pain disorders have been published with conflicting results.^{87–95} A review from 2004 concluded that there is insufficient evidence to support thermography use in routine clinical practice.⁹⁶ Two articles published in 2013 investigated the use of thermography in the diagnosis of TMJ arthralgia and myogenous TMDs, finding low diagnostic accuracy for both.^{97,98} To date, the use of thermography for the diagnosis of TMDs or other orofacial pains remains unproven. The available evidence remains insufficient to conclude that thermography has a beneficial impact on either diagnosis or treatment outcomes. Furthermore, standards for image evaluation and cutoff values that may allow clinical decision making have yet to be established.

Sonography

Doppler sonography data are similar to the data obtained with vibration analysis (see below) but with use of sound recordings instead of joint vibrations. Although Doppler sonography has been suggested for diagnosing TMDs based on the detection of joint sounds, the clinical significance and reproducibility of sounds emanating from the TMJs is not reliable.^{82,99} Studies evaluating sonography for the diagnosis of articular disc displacement have found that both clinical and sonographic examination had a high sensitivity but a low specificity compared with MRI findings.^{99–101} Since the last edition of the *AAOP Guidelines* was published, no new data has been published to

justify the use of sonography for detection of TMJ sounds and internal derangements in lieu of clinical palpation and auscultation. Hence, there is insufficient evidence to justify the use of sonography for the diagnosis of TMDs.

Vibration analysis

Vibration analysis is similar to sonography in using joint sounds to assist in the diagnosis of TMDs with internal derangements.^{102–108} Sensitivity and specificity are less than desired, with many false negatives and false positives.¹⁰⁷ A systematic review investigated the usefulness of joint vibration analysis in the diagnosis of TMD. The authors concluded that the literature failed to establish reliability and validity and that the use of vibration analysis in TMD diagnosis was unconvincing.¹⁰⁸

Diagnostic imaging of the TMJ

There are a number of diagnostic imaging modalities that may confirm the presence of suspected pathosis, rule out disease, and stage various diseases affecting the orofacial region.^{109–111} Imaging should not be done routinely for every patient or as an initial diagnostic test. Appropriate imaging can gather additional information when the clinical diagnosis remains equivocal or unclear. Similarly, the presence of unusual signs and symptoms and the failure of conservative management strategies are indications for the use of appropriate imaging. The optimal type of imaging to be employed depends upon the presenting symptoms and clinical examination findings of the individual patient.¹⁰⁹ When abnormalities are suspected or identified that fall outside the scope of an individual's training and experience, then appropriate referral should be made for medical specialist diagnosis and management.

Panoramic radiography, also known as *orthopantography*, is a type of tomography in which the maxilla and the mandible are depicted on a single film. The panoramic radiograph is useful for screening for gross dental

and periodontal pathology, as well as other maxillary and mandibular disorders and diseases. After intraoral dental radiographs, it remains the most common radiographic study performed in a dental office. However, as far as TMJ imaging is concerned, the projected image is inaccurate and cannot be used for diagnostic purposes.¹¹² Conventional tomography, apart from the panoramic radiograph, has essentially been replaced by computed tomography (CT) procedures.

CT is predominantly used where primary bony pathoses are suspected clinically. CT is particularly useful for evaluating degenerative and arthritic changes, fractures, bony cysts, infection, tumor invasion, and other pathology. The newer multidetector CT (MDCT) also has utility for soft tissues, and using appropriate protocols, the TMJ articular disc and presence of intra-articular effusion can be demonstrated.^{113,114} Because soft tissue findings can be critical, this is a significant advantage over cone beam CT (CBCT). In general, however, it is considered that soft tissue lesions, the TMJ articular disc, and associated soft tissues are best evaluated with MRI. Relative advantages of CT over MRI include exquisite bone details and three-dimensional assessment of congenital, traumatic, and postsurgical conditions.¹⁰⁹

CBCT for the maxillofacial region has become readily available and is increasingly used in dentistry.^{115,116} The advantages of CBCT over MDCT are lower cost, slightly higher resolution, and lower radiation dose. However, with appropriate protocols, the radiation doses now delivered by modern MDCT scanners are comparable to CBCT. CBCT is useful for evaluation of osseous abnormalities of the orofacial region. However, relative weaknesses include longer imaging times and related potential for motion artifact, low signal-to-noise ratios, beam hardening, and absence of soft tissue detail.

MRI represents the current gold standard of diagnostic imaging technology for soft tissues.¹⁰⁹ MRI does not use radiation and so is considered biologically safe. The high resolu-

tion and great soft tissue contrast of MRI afford detailed evaluation of TMJ anatomy, as well as TMJ biomechanics, through open and closed mouth views. MRI enables a determination of the position and morphology of the TMJ articular disc as well as condylar bone morphology. Inflammatory changes such as intra-articular effusion and condylar bone marrow edema are also demonstrated. In consideration of these factors, MRI is considered the imaging modality of choice for the diagnosis of TMJ internal derangements.^{117–121} In the comprehensive assessment of orofacial pain, MRI can also be used to rule out intracranial causes of pain in patients with trigeminal neuropathic pain or headaches.

Arthrography of the TMJ involves injection of radiopaque dye into the TMJ that outlines the articular disc under video fluoroscopy. Arthrography is rarely used today, having been replaced by MRI, which noninvasively provides superior information of all the TMJ structures without exposing the patient to radiation.

Nuclear medicine studies involve the intravenous administration of a radioactive isotope (eg, technetium), the uptake of which enters into tissues and is measured via either a scintillation gamma camera or single-photon emission CT (SPECT).¹¹¹ These tests have particular utility in identifying fractures, malignancy, infections, and other diseases involving bone.¹⁰⁹ Scintigraphy is useful to determine bone growth activity in hyperplastic TMJ condyles where TMJ surgery is being considered.¹²² Scintigraphy is a highly sensitive but very nonspecific test with regard to identifying a specific disease or disorder. A recent study concluded that cross-sectional SPECT is more sensitive than traditional planar scintigraphy in the diagnosis of condylar hyperplasia.¹²²

Ultrasonography (US) is generally not considered a conclusive diagnostic tool for TMJ articular disc derangements.¹²³ A systematic review concluded that US can exclude rather than confirm TMJ articular disc derangements.¹²⁴ An evidence-based review of this

study confirms these findings.¹²⁵ US may also be used for the image-guided injection of medications (eg, corticosteroids, hyaluronic acid, or platelet-rich plasma) into individual muscles and the lower joint space of the TMJ.¹²⁶ US is also a very useful technique for evaluating the soft tissues of the head and neck region, especially the salivary glands and masses of uncertain origin and nature on clinical examination. US and US-guided fine-needle aspiration cytology are also excellent diagnostic techniques when indicated.¹²⁷

Functional neuroimaging of orofacial pain and headache has been the focus of many studies over the last few years. Various methods, including functional MRI, magnetoencephalography (MEG), positron emission tomography (PET) and SPECT, record patterns of changes in voltage, current, magnetic fields, neurochemicals, and blood flow spatially in the brain. Magnetic resonance spectroscopy can noninvasively assess different metabolites and neurotransmitters in the brain. Near-infrared spectroscopy can detect changes in blood hemoglobin concentrations associated with neural activity and has great potential in measuring effects of pain upon the brain. Functional neuroimaging studies of migraine, trigeminal neuropathic pain, TMDs, and toothache are furthering our understanding of the anatomical and pathophysiologic mechanisms of these and other orofacial pain disorders.¹²⁸

Neurosensory testing

Neuropathic pain is “caused by a lesion or disease of the somatosensory nervous system.”¹²⁹ If the patient’s history indicates the possibility of a lesion or disease that can affect the peripheral or central somatosensory system, and the pain has a distinct neuroanatomically plausible distribution, then painful neuropathy is likely. Painful neuropathy is characterized by its burning, prickling, electrical, and sharp nature. Painful neuropathy can be spontaneous or evoked with distinctive associ-

Table 2-4 Diagnostic anesthesia

| Type of anesthetic block | Type of pain |
|------------------------------------|--|
| Dental block | Odontogenic pain or neuropathic pain |
| Trigger point injections | Myofascial pain and headache |
| Trigger zone infiltration | Trigeminal neuralgia |
| Auriculotemporal nerve block | Intracapsular TMJ pain |
| Intracapsular block | Intracapsular TMJ pain |
| Greater and lesser occipital block | Cervicogenic pain and headache |
| Sphenopalatine block | Neuropathic facial pain Neurovascular pain Sympathetically maintained pain |
| Stellate ganglion block | Sympathetically maintained pain |

ated positive (ie, heightened sensation) signs (eg, spontaneous pain, allodynia and hyperalgesia) and/or negative (ie, sensory deficit) signs. There is almost always an area of abnormal sensation.

Neurosensory tests assessing changes in responsiveness to different types of somatosensory stimuli have been adapted for use in the orofacial region and are an important part of the clinical examination. A quick and easy chair-side technique can be used, or the patient can be referred to a specialized university setting or pain clinic for comprehensive quantitative sensory testing (QST).^{130,131} This type of testing allows noninvasive assessment and quantification of sensory nerve function in patients with suspected neurologic disease or neuropathy. Various mechanical, thermal, and electrical stimuli can be applied to the affected area, and the evoked responses can be measured. The responses can be compared with normal contralateral sites or established normal QST ranges. Alternatively, different stimuli can be

applied to establish either pain or other sensory threshold levels. Specific QST modalities can be used to activate different types of sensory nerve fibers, allowing insight as to pathologic processes. At this time, the use of QST in the trigeminal system is undergoing research and development and is not yet considered as established for routine clinical practice.¹³¹

Diagnostic anesthesia

Neural blockade, both somatic and sympathetic nerve blocks, and myoneural (trigger point) injections may be used as diagnostic tools (Table 2-4). Examples of somatic nerve blocks in the head and neck include trigeminal, supraorbital, infraorbital, greater occipital, sphenopalatine ganglion, and cervical plexus nerve blocks. Somatic neural blockade is not only used to determine whether or not pain is emanating from a particular nerve, but it may also be used to determine whether the source of pain is proximal or distal to a particular site along the nerve.¹ In addition to its diagnostic potential, somatic neural blockade may be useful as a therapeutic agent by providing pain relief to the affected area by breaking the cycle of pain.

Lidocaine (1% to 2%, often with epinephrine) is recommended for diagnostic nerve blocks because it produces a prompt, long-lasting, and extensive anesthesia. Neural blockade is of particular prognostic value prior to neurolytic blockade or surgical sympathectomy (neurolysis). When prolonged anesthesia is desired for pain management, bupivacaine (0.25%) can be used.

Primary musculoskeletal pain, meaning pain in an injured or painful muscle or joint that can be provoked, may be arrested by a local or regional anesthetic block. The TMJ can be anesthetized by a lateroposterior and slightly inferior intracapsular approach, a posterior meatal intracapsular approach, or an extracapsular block of the auriculotemporal nerve at the posterior aspect of the neck of the condyle.¹ Myofascial pain may be eliminated only if the

anesthetic blocks the source or primary site of pain.¹ Therefore, an equivocal diagnostic injection of a myofascial trigger point suggests that the source of pain has not been discovered, while an effective injection can allow the clinician to be confident that the source of pain has been found.¹ Lidocaine 2% (without epinephrine) or mepivacaine 3% are suitable for this purpose. Bupivacaine appears to be relatively myotoxic and should be avoided for muscle injections.¹³² A number of studies have investigated the use of botulinum toxin injections for the treatment of myofascial TMD pain and/or bruxism.^{133–137} However, there are no data to suggest that botulinum toxin can be used in a diagnostic sense.

If a regional block, such as a mandibular block, eliminates neuropathic pain distal to the site of injection, the source of pain is located in the region of the anesthetized area. An ineffective diagnostic block suggests that the neuropathic pain is more proximal or central and so may indicate neuroplasticity or involvement of the central nervous system.

Stellate ganglion blocks (sympathetic) and sphenopalatine blocks (parasympathetic) are used for diagnosis and treatment of orofacial pain when an autonomic component is suspected. Performing a stellate ganglion block requires special training and is usually done in an operating room by a trained anesthesiologist. Anesthetizing the sphenopalatine ganglion has been described for treatment of orofacial pain, particularly cluster headache. Conventionally, local anesthetic has been delivered to the area by injection into the pterygopalatine fossa under fluoroscopic guidance, or transnasal application by cotton-tip applicators. Devices have recently been developed to facilitate the procedure that may see increased utility for this type of block.

Diagnostic casts

Because malocclusion is not a common etiology for TMDs (see chapter 8), diagnostic

casts have little value in diagnosis and evaluation in most cases. They are helpful in identifying wear patterns and recording a baseline static occlusion for documentation of occlusal changes during treatment.^{138,139} Dental casts also have utility to help determine whether or not changes at the level of either the teeth or TMJ are responsible for the examination finding of an open bite. If the dental casts are able to achieve maximum intercuspation, it is suggestive that skeletal (TMJ) changes are the cause rather than result of tooth movement. If the dental casts do not achieve maximum intercuspation, changes in the occlusion could be either due to dental movement, skeletal changes, or both. Occlusal analysis is often not accurate when the joints or muscles are tender or painful; therefore, any in-depth evaluation of the occlusion should be performed only after the pain is under control.¹⁴⁰ Even the most accurate casts will not provide enough information by themselves for an accurate diagnosis of joint or muscle pathology.¹⁴¹

Laboratory testing

A comprehensive assessment may include selective serologic testing, but this should not be a routine part of the orofacial pain examination.^{142,143} Blood chemical analysis can rule out hematologic, rheumatologic, metabolic, or other abnormalities suggestive of systemic disease (Table 2-5). The most frequently employed hematologic investigations for orofacial pain are listed in Table 2-6. The clinician should know the appropriate serologic studies and be able to collect and interpret the data to establish a differential diagnosis. If it is established that complaints of orofacial pain are related to a systemic disease, referral to a physician is indicated.

Pretreatment testing and patient monitoring

Specific tests are sometimes necessary before or during certain pharmacotherapeutic treat-

Table 2-5 Laboratory testing for nonodontogenic orofacial pain or TMDs

| Disease | Tests |
|-------------------------------|---|
| Juvenile rheumatoid arthritis | <ul style="list-style-type: none"> • Rheumatoid factor • Antinuclear antibodies • Erythrocyte sedimentation rate |
| Systemic lupus erythematosus | <ul style="list-style-type: none"> • Antinuclear antibodies • Other autoantibodies • Complement • Biopsy |
| Lyme disease | <ul style="list-style-type: none"> • Indirect fluorescent antibody • Enzyme-linked immunosorbent assay • Immunoblotting • Polymerase chain reaction |
| Multiple sclerosis | <ul style="list-style-type: none"> • MRI • Evoked potential studies • Antinuclear antibodies • B₁₂ • Complete blood count • Erythrocyte sedimentation rate • Urinalysis • Elevated myelin levels |

ments.¹⁴² For example, the use of antiepileptic drugs, such as carbamazepine, must be preceded by a baseline complete blood count, a blood differential test, and liver function tests. Tricyclic antidepressant drugs may be preceded by a baseline electrocardiogram for assessment of arrhythmia, especially in older patients.

Renal function

The kidneys are responsible for regulating fluid volume and acid-base balance of the plasma, excreting nitrogenous waste, and synthesizing erythropoietin, hydroxycholecalciferol, and renin. End-stage renal disease occurs when the kidney loses the ability to perform these functions. The early phase of renal disease, which usually is asymptomatic except for some mild laboratory abnormalities, is called *renal insufficiency*. If the proposed medication could exacerbate or initiate renal dysfunction, the patient should be pretested or referred for treatment.

Table 2-6 Frequently used hematologic studies

| Serologic study | Suspicion of |
|--|--|
| Full blood count | Predominantly anemias |
| Hematinics: Ferritin, B ₁₂ , folate | Deficiency states causing secondary burning mouth symptoms |
| Zinc levels | Fe absorption abnormalities |
| Hypothyroidism | Cause of headache |
| HBA1c | Diabetes-related neuropathy |
| Extractable nuclear antigens | Mixed connective tissue disorders and lupus |
| Antinuclear antibody | Various autoimmune and connective tissue disorders |
| Erythrocyte sedimentation rate or C-reactive protein | Inflammatory conditions |

Hepatic function

Some medications can have significant effects on liver function, so knowledge of the status of liver function may be beneficial. In addition, the metabolism of most medications is dependent on liver function. When medications are prescribed that require monitoring of the liver for hepatocellular damage, a liver profile is recommended. Blood chemical analysis is often required prior to and periodically during pharmacologic therapy.

Scheduled drug agreement

On occasion, the clinician may have no other option than to treat a patient with nonmalignant intractable pain with scheduled drugs such as opioids. If the clinician deems this the best course of treatment for the patient, it is recommended that the clinician perform a thorough evaluation of the patient's mental health status and psychosocial situation. The

clinician should discuss the additional risks associated with these drugs, such as physical and psychologic dependence. It is also recommended that the clinician engage in a scheduled drug agreement, in which the responsibilities of both parties are documented. Such responsibilities could include statements that prescriptions should be taken as prescribed, that prescriptions will not be filled early, that the patient agrees not to receive additional similar medications from other health care providers, that the patient is subject to random urine screens and pill counts, and so on. The agreement could restrict the patient to filling his or her prescription at a predetermined pharmacy and indicate that if the patient breaches the agreement, scheduled drugs will no longer be provided, but other forms of treatment will be offered. The goal of treatment is to reduce pain, to improve function, and to increase quality of life. If these goals are not achieved with this type of treatment, the patient should be weaned off the medications and alternative treatments offered. Because cognitive impairment could be a side effect with long-term use of these medications, patients should be routinely tested for such side effects. The clinician may desire the assistance of a qualified health psychologist to provide this assessment.

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Diagnostic Classification of Orofacial Pain

Key Points

- ◇ Diagnostic systems are needed to assist with management of orofacial pain.
- ◇ There are many widely varying diagnostic schemes, which reflects the complexity of pain as a field.
- ◇ No diagnostic classification is without shortcomings and criticism, and there is still an urgent need for validation of classification schemes.
- ◇ The diagnostic classification presented in this chapter is in accord with internationally accepted standards and should be useful for clinicians attempting to manage patients who are suffering from orofacial pain.

The ability to understand and investigate the pathophysiologic processes underlying a disorder depends on a valid, reliable classification system and common terminology to facilitate communication among clinicians, researchers, academics, and patients. Without a universal system of organization in place, discussion, investigation, and ultimately understanding of the disorder are difficult to achieve.

Classification begins by grouping disorders according to common signs and symptoms and then dividing further by common pathophysiology and treatment approaches. In this manner, the diagnostic classification can assist clinicians in treatment selection. From a clinical perspective, it is not important to further divide subgroups when all of the disorders within a given subgroup are managed by the same therapy; therefore, from a therapeutic standpoint, subcategories are only useful when therapy demands it.

Another purpose of a common diagnostic classification system is to assist researchers in gaining insight into the prevalence, etiology, and natural course of a specific disorder. Knowledge can only be advanced when there is agreement on specific disorders so that research efforts can be compared between patients and various research groups. At this time, it is uncertain whether diagnostic criteria for research purposes are compatible with diagnostic criteria for determining therapy. For example, it is quite reasonable to separate muscle disorders from intracapsular joint disorders for the purpose of studying the natural course of these disorders. However, merely identifying that a patient is suffering from one of these types of disorders may not be adequate to effectively manage the condition. The most useful classification system would provide both research and diagnostic advantages.

The process of developing a classification system begins by identifying a group of common signs and symptoms. Once these signs and symptoms have been identified, the disorder is named. The disorder, with its common signs and symptoms, is then investigated to learn more about its etiology so that effective treatment may be developed. It is very important that the signs and symptoms used to identify the disorder be unique to the disorder so that other unrelated disorders are not misidentified. It is therefore necessary to develop specific inclusion and exclusion criteria that will permit accurate grouping of similar disorders. To eliminate as much variability in diagnosis as possible, it is very important to be specific, avoiding words such as “usually,” “typically,” or “sometimes.” Testing is then necessary to determine if the diagnostic criteria are valid and reliable for determining the disorder. Once they are proven reliable, research efforts can be directed toward gaining better insight into etiology, eventually leading to more effective treatment.

In this chapter, past and present terminology and diagnostic classification systems for temporomandibular disorders (TMDs) and orofacial pain disorders are discussed, and a classification system for orofacial pain disorders is presented. To assist the reader, the codes from *The International Classification of Diseases, Tenth Edition (ICD-10)* will be provided for each diagnosis throughout the next chapters.

Terminology

Over the years, functional disturbances of the masticatory system have been identified by a variety of terms, which likely led to confusion in this area. In 1934, Dr James Costen¹ described a group of symptoms that centered around the ears and temporomandibular joints (TMJs), which became known as *Costen syndrome*. In 1959, Shore² used the term *temporomandibular joint dysfunction syndrome* for those symptoms. Later, the term *functional temporomandibular joint disturbances* was introduced by Ramfjord and Ash.³ Some earlier terms, such as *occlusomandibular disturbance* and *myoarthropathy of the temporomandibular joint*, were based on possible etiologic factors.^{4,5} Other terminology stressed the featured pain symptom, such as *temporomandibular pain-dysfunction syndrome* and *myofascial pain-dysfunction syndrome*.^{6,7}

Because the symptoms are not always isolated to the TMJs, some authors believe that the previously mentioned terms were too limited and a broader, more collective term should be used, such as *craniomandibular disorders*.⁸ Bell⁹ suggested the term *temporomandibular disorders*, which has gained wide acceptance and popularity. As described in this text, this term includes not only problems related to the TMJ but all functional disturbances of the masticatory system. Any musculoskeletal disorder of the masticatory system can be considered a TMD.

Diagnostic Classification Systems

History of classification systems

A review of the literature regarding the classification of orofacial pain reveals little consensus on the most favorable diagnostic classification system. Many classification systems with varying advantages and disadvantages have been offered. Categories of division included etiologic factors, common signs and symptoms, tissue origin or functional region of the body, or combinations thereof. Perhaps the first classification system for TMJ problems was offered by Weinmann and Sicher.¹⁰ In 1951, they classified TMJ problems into (1) vitamin deficiencies, (2) endocrine disorders, and (3) arthritis. Five years later, Schwartz¹¹ introduced the term *temporomandibular joint pain-dysfunction syndrome* to distinguish organic disturbances of the joint proper from masticatory muscle disorders. In 1960, Bell¹² developed a classification composed of six groups, recognizing both intracapsular and muscle (ie, extracapsular) disorders. Acknowledging the need for a suitable classification for functional disorders of the masticatory system, the American Academy of Orofacial Pain (AAOP) published a position paper with a suggested classification system.⁸ Soon after, the American Dental Association (ADA) organized a national conference in which Bell suggested the term *temporomandibular disorders*, and a revised classification of TMDs consisting of five categories was introduced. Both the term and the classification were accepted by the ADA, but unfortunately, no diagnostic criteria were offered at that time.¹³

In 1989, Stegenga et al¹⁴ proposed a system of classification emphasizing TMJ articular disorders. They divided their classification into inflammatory and noninflammatory articular disorders and nonarticular disorders. The subcategories of osteoarthritis and internal derangements were further divided according to staging over time. Although this classification

provided insight to intracapsular disorders, it placed little emphasis on masticatory muscle disorders. No diagnostic criteria were offered with this classification. As the dental profession began to appreciate the similarity between many TMDs and other medical conditions, a need grew to include TMDs in a more inclusive medical classification for pain disorders. In 1986, the International Association for the Study of Pain (IASP)¹⁵ published a classification of pain conditions. Of the 32 categories of pain disorders, category III was designated as “craniofacial pain of musculoskeletal origin.” Within this category were two subcategories: (1) temporomandibular pain and dysfunction syndrome; and (2) osteoarthritis of the TMJ. This classification failed to recognize any pain disorders arising from the masticatory muscles.

In 1990, the American Academy of Head, Neck, Facial Pain and TMJ Orthopedics¹⁶ proposed a classification with five TMD categories and two non-TMD categories. The subcategories represented a mixture of both traditional and nontraditional disorders. Brief explanations were offered for most subcategories but not for all. There were 19 subcategories under the main category of “myofascial disorders,” some of which were separated by the specific muscle or tendon involved. Some diagnostic categories, such as “bruxism,” might better represent a precipitating or contributing factor of muscle pain and not necessarily a muscle pain disorder itself. No diagnostic criteria were offered to assist in classifying these disorders.

Another classification suggested a much broader approach. Woda and Pionchon¹⁷ proposed the adoption of a unifying classification for “idiopathic orofacial pain disorders.” Most clinicians who treat orofacial pain disorders recognize that there are certain patients who present with clinical symptoms that do not easily fit into the known and generally well-accepted classifications of orofacial pain disorders. The authors suggest that many of these unclassified conditions present with some common clinical symptoms. Because

our understanding of these disorders is not complete, the profession has assigned such terms as *atypical facial pain* and *atypical odontalgia*. These atypical cases may present with common clinical symptoms associated with common pathophysiologic mechanisms. If common mechanisms do in fact exist, then it may be useful to group these conditions together. Yet until these mechanisms are better understood, grouping them into a large classification will not likely improve treatment selection. In fact, it would appear that placing TMDs with relatively known etiologies and treatment strategies into a group of idiopathic orofacial pain disorders would be taking a step in the wrong direction.

In 2012, a group of researchers and clinicians attempted a new approach to the classification of orofacial pain, which was based on ontology.¹⁸ *Ontology* is the study of the nature of being, such as whether an entity exists or not, how entities are similar and different as well as how they relate to each other within a hierarchy, and how these differences or similarities define their subgroup.¹⁹ Identifying a disorder or disease is dependent on several levels of evidence, such as reality, observations, interpretations, and/or beliefs. This new endeavor to classify orofacial pain has only attempted to examine a few orofacial pain conditions, and therefore a full classification is not available. This approach to nosology is unique, and its usefulness has yet to be demonstrated.

In 2014, the Analgesic, Anesthetic, and Addiction Clinical Trial Translations Innovations Opportunities and Networks (ACTTION) and the American Pain Society (APS) developed a mechanistic chronic pain classification system called the ACTTION-APS Pain Taxonomy (AAPT), which describes pain in five dimensions: (1) core diagnostic criteria; (2) common features; (3) common medical and psychiatric comorbidities; (4) neurobiologic, psychosocial, and functional consequences; and (5) putative neurobiologic and psychosocial mecha-

nisms, risk factors, and protective factors. In the AAPT, “temporomandibular disorders” and “other orofacial pain” are organized in the “orofacial and head pain system.”^{20,21}

The ICHD

In 1988, the International Headache Society (IHS) proposed their first classification for headache composed of 13 broad categories, called the International Classification of Headache Disorders (ICHD).²² The 11th category was designated as “headache or facial pain attributed to disorder of cranium, neck, eyes, ears, nose, sinuses, teeth, mouth, or other facial or cranial structures.” There were no specific subcategories related to TMDs, despite recommendations by the AAOP.²³ In 2004, the IHS published their second version of the classification, outlining more than 230 types of headaches. TMDs were still minimally addressed in this version under category 11.²⁴ The AAOP provided diagnostic criteria and subcategories from the third and fourth editions of this book in 1996 and 2008, respectively.^{25,26} In 2013, the IHS published a beta version of the third edition of the ICHD, which is the classification system used in this text for headaches and neuropathic pain.²⁷ Over the past few years, many clinicians have embraced this classification because of its inclusive considerations for all head pains. This classification offers more than 300 types of headaches and thus requires the clinician to possess a very high level of appreciation for all head pain disorders before a diagnosis can be properly established. In this version, only “Headache attributed to temporomandibular disorder (TMD)” is addressed under category 11.

The RDC/TMD and DC/TMD

In 1992, Truelove et al²⁸ proposed a classification system for TMD that allowed for multiple diagnoses within the same subject group. Required operational criteria were listed for each

diagnostic group, allowing the researcher to investigate a sample population and determine the types and severity of disorders present. This concept was further elaborated through the research diagnostic criteria (RDC) offered by Dworkin and LeResche.²⁹ This classification not only provided very specific diagnostic criteria for eight TMD subgroups—it also recognized another level or axis that must be considered when evaluating and managing TMD pain: the psychosocial component. For the first time in any classification system, a dual diagnosis was established that recognized the physical conditions (Axis I) and psychologic conditions (Axis II) that contribute to the suffering, pain behavior, and disability associated with the patient's pain experience. (This Axis II should not be confused with the designated axis system endorsed by the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition [DSM-5]* of the American Psychiatric Association.) This dual-axis classification approach has been incorporated in Bell's classification for all orofacial pain disorders.³⁰

The RDC offered what appeared to be reasonable diagnostic criteria, specifically for research purposes.²⁹ Although some questioned whether these criteria were specific enough to accurately distinguish subgroups of TMD patients, the use of Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) for the most common TMDs has acceptable reliability.^{31–34} The International RDC-TMD Consortium from the International Association for Dental Research and the Special Interest Group on Orofacial Pain from the IASP joined forces to revise the RDC/TMD diagnostic algorithms to produce the dual-axis Diagnostic Criteria (DC/TMD) for the most common pain-related TMDs. These are evidence-based, have improved diagnostic accuracy, and are easy to use by both clinicians and researchers.³⁵ The validation project established high sensitivity and specificity for the painful musculoskeletal TMDs and high specificity for disc derangements in the DC/TMD.^{36,37}

Peck et al³⁸ expanded on the DC/TMD taxonomy in 2014 to include less common—but still clinically relevant—disorders such as adhesions, ankylosis, idiopathic condylar resorption, synovial chondromatosis, tendonitis, masticatory muscle spasm, movement disorders, and coronoid hyperplasia. This list of 37 disorders all featured plausible diagnostic criteria that could be operationalized and further studied.³⁸ An executive summary of the DC/TMD published in the *Journal of the American Dental Association* in 2016 promoted this evidence-based, biopsychosocial approach to TMD classification with the wider dental audience.³⁹ Future directions for the DC/TMD may include (1) incorporating synovial fluid biomarkers for TMJ arthritis; (2) developing longitudinal trials to evaluate the predictive role of demographics, function, and structure in the progression of disc-condyle disorders; (3) validating whether myofascial pain and myofascial pain with referral are the same or separate entities; (4) clarifying the etiologic, diagnostic, and management overlap of sleep and awake bruxism, orofacial dyskinesia, and oromandibular dystonia; (5) reconciling the ICHD and DC/TMD definitions of headache attributed to TMD; and (6) establishing the most efficient and effective Axis II biobehavioral screening instruments for use in the clinical setting.⁴⁰

Future directions

The upcoming *ICD-11* will make considerable advances in the classification of chronic pain, spearheaded by the IASP Task Force for the Classification of Chronic Pain on behalf of the World Health Organization (WHO). Slated for release in 2018, the *ICD-11* (which can be accessed as a beta draft on the WHO website) allows for cross-referenced categories. Chronic pain disorders are divided into seven groups: primary pain, cancer pain, posttraumatic and postsurgical pain, neuropathic pain, headache and orofacial pain, visceral pain, and muscu-

loskeletal pain. For example: “chronic headache and orofacial pain” would encompass TMDs and posttraumatic trigeminal neuropathy (PTTN), with the PTTN cross-referenced to chronic neuropathic pain. The *ICD-11* organizes chronic pain entities first according to their etiology, then the pathophysiologic mechanism underlying the pain, and then the location of pain in the body.⁴¹

Although it would be desirable, there is no current single all-encompassing chronic pain classification system to unify and streamline patient care worldwide.⁴² However, significant strides have been made in the last 25 years, and future efforts could streamline chronic orofacial pain classification by focusing on hypothesis-driven descriptions and interrelations of disease entities, incorporating physiologic and psychosocial domains, beta-testing the classifications for sensitivity and specificity, and designing the classifications for clinical implementation.⁴³ Incorporating genetic markers, neurobiologic pain processing changes over time, and ontologic principles could generate an even more comprehensive and unifying classification system.⁴⁴

Differential Diagnosis of Orofacial Pain

The diagnostic process is a clinical skill that joins science and art. The goals of the process are to determine the existence of any primary and/or secondary physical (Axis I) or psychologic (Axis II) diagnoses, the contributing factors, and the level of complexity of the patient’s problem(s), including the prognosis. Listing conditions that may be responsible for each of the presenting complaints of the patient, as well as other factors that may contribute to the complexity of the tentative diagnosis, usually facilitates the process. The diagnostic process involves defining the inclusion criteria that are specific to a disorder and ruling out specific disorders that can cause

similar symptoms. This should be done from a diagnostic classification that includes all possible disorders. It is important to rule out serious, life-threatening intracranial or extracranial disorders or diseases early in the diagnostic process because these conditions may require immediate care. Pain sources should be pursued until all correct diagnoses are established using inclusive diagnostic criteria. The process of differential diagnosis is critical because an incorrect or omitted diagnosis is one of the most frequent causes of inappropriate and misdirected treatment or treatment failure.

Establishing the correct diagnosis in patients with orofacial pain is particularly difficult because of the complex interrelationship of physical and psychologic factors in the etiology of biopsychosocial chronic pain syndromes. Many disorders have similar signs and symptoms. If the source of painful symptoms is uncertain, the appropriate diagnosis is “pain, cause unknown or undetermined.” Although individual clinicians can be successful in diagnosing the simpler orofacial problems, a multidisciplinary team approach is often required for diagnosing and managing complex chronic orofacial problems, especially when Axis II factors are present or significant other comorbidities exist, including central sensitization, irritable bowel syndrome, pelvic pain, chronic headache, and chronic low-back pain.⁴⁵⁻⁵¹

The guidelines in this text incorporate the classification structures proposed by the Taxonomy Committee of the International RDC-TMD Consortium Network and the Special Interest Group on Orofacial Pain, as presented in the expanded DC/TMD³⁶ (see Box 8-1) for TMDs, as well as the ICHD for headaches and neuropathic pain. The broad categories included in these guidelines are as follows:

- Vascular and nonvascular intracranial pain disorders
- Primary headache disorders
- Neuropathic pain disorders
- Intraoral pain disorders

- Temporomandibular disorders
- Cervical pain disorders
- Extracranial and systemic causes of orofacial pain

Each of these categories represents a group of Axis I physical orofacial pain conditions. Another category will be included to review the Axis II psychologic factors that are commonly associated with orofacial pain disorders. The seven broad categories of orofacial pain (Axis I) are briefly introduced in this chapter along with the Axis II considerations. An additional section includes how sleep disorders may influence these conditions. A more complete description of each is presented in separate chapters.

Vascular and nonvascular intracranial pain disorders

Disorders of the intracranial structures (eg, neoplasm, aneurysm, abscess, hemorrhage or hematoma, and edema) should be considered first in the differential diagnosis because they can be life-threatening and may require immediate attention. The characteristics of serious intracranial disorders include new or abrupt onset of pain or progressively more severe pain, interruption of sleep by pain, and pain precipitated by exertion or positional change (ie, coughing, sneezing). Other characteristics of intracranial disorders are signs or symptoms of weight loss, ataxia, weakness, fever with pain, neurologic signs or symptoms (eg, seizure, paralysis, vertigo), and neurologic deficits.^{28,44}

Primary headache disorders

Primary headache disorders are a group of pain disorders that have their origin in both neurologic and vascular pathology. Because some of these headaches appear to have a neurologic mechanism that triggers a vascular response,

they are frequently referred to as *neurovascular*. Headaches that comprise this category include migraine, tension-type headache, and trigeminal autonomic cephalalgias. The characteristics of these headaches vary. Migraine for example is described as throbbing, pulsating, and disabling, whereas tension-type headache is characterized as a dull, steady aching pain. The dental profession has become increasingly active in managing some of these pain disorders; however, the major burden of managing most of these disorders still lies within the medical community.

Neuropathic pain disorders

Neuropathic pain is defined as pain caused by a lesion or disease of the somatosensory nervous system.⁵² These pain conditions arise from functional abnormalities of the nervous system.^{53–55} Because the somatic structures are not affected, the examination fails to reveal any obvious cause or pathology. An ideal classification for neuropathic pain would be based on the mechanisms that are responsible for producing the pain condition.^{56–58} Unfortunately, our current understanding of these conditions is not sophisticated enough to achieve this. Complicating the development of a classification system for neuropathic pain is the understanding that both the peripheral and central nervous systems contribute to these pain conditions, often at the same time. Terms such as *persistent dentoalveolar pain disorders* and *peripheral painful traumatic trigeminal neuropathies* have been proposed to describe neuropathic pain conditions with peripheral etiologies in the facial region.^{22,59,60} Classic trigeminal neuralgia appears to be caused by a central mechanism initiated by peripheral stimulation. These examples reflect the difficulty in developing an encompassing classification for neuropathic pains. Several episodic as well as a variety of continuous neuropathic pains are described.

Intraoral pain disorders

Intraoral pain is the most common source of orofacial pain. The dentist plays an important role in the diagnosis of intraoral pain because many of these disorders are solely managed by those in the dental profession. The dentist must be extremely thorough in ruling out intraoral pain disorders involving the dental pulp, periodontium, mucogingival tissues, and tongue.

Temporomandibular disorders

TMDs include disorders involving the masticatory muscles and/or the TMJ. TMDs have been identified as a major cause of nonodontogenic pain in the orofacial region and are considered a subclassification of musculoskeletal disorders.⁶¹

Cervical pain disorders

Cervical pain disorders represent a very common group of musculoskeletal conditions that can greatly influence the orofacial structures. These disorders are subdivided into those that predominantly originate in the muscles and those that predominantly originate in the cervical spine. These structures very commonly refer pain to the face and therefore deserve a significant diagnostic consideration.⁶²

Extracranial and systemic causes of orofacial pain

There are a variety of associated structures that can cause orofacial pain, such as the ears, eyes, nose, paranasal sinuses, throat, lymph nodes, and salivary glands. Many of these structures produce heterotopic (ie, referred) pain felt in the orofacial region, which is often misinterpreted as dental or TMD pain. Although pain from these structures may not be primarily managed by the dentist, a thorough understanding of their characteristics is necessary to establish an accurate diagnosis and

avoid inappropriate interventions. Once the diagnosis has been established, proper referral should be considered.

Sleep disorders

The presence of pain, especially chronic pain, greatly interferes with the duration and quality of sleep. As will be discussed in chapter 11, the quality of sleep is vital for maintaining physical and psychologic health, and poor-quality sleep can actually initiate pain experiences in some individuals. It is very apparent that pain and sleep are often closely associated conditions for many chronic pain patients. The orofacial pain clinician needs to appreciate this relationship, and a chapter on sleep disorders has therefore been included in this text.

Axis II: Psychologic factors

There are many psychologic factors that contribute to the patient's pain experience. In fact, rarely does pain exist without some influence of these Axis II factors, especially as pain becomes more chronic. Even common stressful life events, such as conflicts in home or work relationships, financial problems, and cultural readjustment, may contribute to illness and chronic pain.^{63–66} These stressors may heighten tensions, insecurities, and dysphoric affects, which may in turn lead to increased strains on the masticatory system by way of unusual parafunctional behaviors. Once established, these adjustment reactions (often with mixed disturbance of emotions and conduct) lead to an upregulation of the autonomic nervous system, which can further exacerbate the physical condition.^{67,68}

Depression, anxiety, and prolonged negative feelings are common among chronic pain patients and may make the persistent pain more difficult to tolerate or manage. Negative cognitive factors, such as counterproductive thoughts or attitudes, can make resolution of the illness more difficult. Confusion and mis-

understanding are commonly seen in chronic pain patients because they have often received many opposing and varied opinions, diagnoses, and treatment suggestions. This confusion reduces motivation and increases anger or non-compliance. Also, patients with persistent pain often have unrealistic expectations and may expect complete or immediate pain relief.

It should be emphasized that mental disorders and orofacial pain disorders are not mutually exclusive conditions. When psychologic factors are prominent in the patient's presentation, collaboration with a mental health care professional should be an integral dimension of assessment and management.

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Vascular and Nonvascular Intracranial Causes of Orofacial Pain

4

Key Points

- ◇ A systematic approach to patient history and clinical examination is critical to identifying patients with secondary etiologies of headache.
- ◇ Intracranial causes of head, neck, and orofacial pain are numerous and may lead to disability or death if not managed promptly.
- ◇ Rapid neurologic referral is warranted if patients present with neurologic symptoms and findings.
- ◇ Diagnoses of intracranial causes of head, neck, and orofacial pain rest primarily on a careful history, a healthy respect for red flags, and a willingness to rapidly evaluate further.
- ◇ The SNOOP4 acronym is a useful mnemonic device for screening each patient.

This chapter reviews both vascular and nonvascular intracranial sources of orofacial pain, many of which may be life-threatening or associated with significant morbidity if left untreated (Box 4-1). The codes from International Classification of Headache

Disorders, third edition (beta version) (ICHD)¹ are provided for each disorder.

Preliminary Investigation

Although only a minority (approximately 1%) of patients presenting to the clinic with a headache will ultimately be found to have a significant abnormality on neuroimaging, the consequences of a missed diagnosis can be catastrophic. In the emergency room setting, the probability of a significant abnormality on neuroimaging increases to up to 8%. Predictive factors include acute-onset headache, age above 50 years, and an abnormal neurologic examination.² Though neuroimaging is an important diagnostic tool, many secondary headache syndromes may be overlooked with neuroimaging alone, including giant cell arteritis (GCA), idiopathic intracranial hypertension, and cardiac cephalgia. The decision to treat or investigate begins with a careful history and physical examination, which can be aided by the mnemonic *SNOOP4* to screen for red-flag features³ (Box 4-2). Because many intracranial structures are insensitive to pain (Box 4-3), intracranial pathologic processes must be diagnosed according to other concomitant symptoms or historic facts.⁴

Systemic symptoms or disease

Pain in addition to systemic features such as fever, weight loss, arthralgia, stiff neck, or rash could indicate meningoencephalitis, bacteremia/sepsis, vasculitis (eg, GCA), or neoplastic processes. Preexisting risk factors, such as human immunodeficiency virus (HIV), cancer, or chronic treatment with immunotherapy predispose patients to systemic disease. HIV is associated with both intracranial infections and cancer.

Neurologic signs or symptoms

Neurologic signs or symptoms, ranging from mild confusion or sedation to frank neurologic deficits such as aphasia or hemiparesis, typically indicate more than a primary pain disorder. At times, migraine attacks can be accompanied by neurologic changes such as aphasia, hemisensory symptoms, visual field defects, and/or hemiparesis (ie, aura), but a diagnosis first requires exclusion of secondary causes. For example, the temporal profile of aura is typically gradual and slowly progressive and is associated with positive features (eg, scintillating scotoma), whereas stroke is associated with an abrupt, static onset of negative features (eg, vision loss). Focal neurologic signs and symptoms such as hemiparesis, visual obscuration, diplopia, dizziness/vertigo, imbalance, or numbness warrant further investigation to rule out vascular, infectious, inflammatory, and neoplastic disease of the brain and/or meninges. Patients may ultimately be diagnosed with a primary headache disorder such as migraine with aura or an uncommon variant such as migraine with brainstem aura or hemiplegic migraine.

Onset sudden (thunderclap)

A sudden-onset, severe, and generalized or localized headache must be considered serious until proven otherwise. The differential diagnosis for life-threatening acute-onset headaches includes (1) vascular disorders such as subarachnoid hemorrhage (SAH), cerebral infarction, cerebral venous thrombosis, and cervical artery dissection and (2) nonvascular disorders such as pituitary apoplexy and central nervous system infections. To rule out SAH in a patient presenting with sudden-onset headache, the American College of Emergency Physicians recommends a diagnostic approach that comprises the use of a computed tomography (CT) image of the head followed by a lumbar puncture.⁵ Other testing, such as noninvasive

Box 4-1 Life-threatening secondary causes of orofacial pain**Vascular disorders**

- Ischemic cerebrovascular disease (ICHD 6.1)
- Traumatic intracranial hemorrhage (ICHD 5.5)
- Nontraumatic intracranial hemorrhage (ICHD 6.2)
- Unruptured vascular malformation (ICHD 6.3)
- Arteritis (ICHD 6.4)
- Carotid or vertebral artery pain (ICHD 6.5)
- Venous thrombosis (ICHD 6.6)

Nonvascular disorders

- High cerebrospinal fluid pressure (ICHD 7.1)
- Low cerebrospinal fluid pressure (ICHD 7.2)
- Intracranial noninfectious inflammation (ICHD 7.3)
- Intracranial neoplasm (ICHD 7.4)
- Intracranial infection (ICHD 9.1)

Box 4-2 SNOOP4: Acronym for signs and symptoms of concern³**Systemic symptoms or disease**

Fever, weight loss, HIV, systemic cancer

Neurologic signs or symptoms

Horner sign, confusion, clumsiness, weakness, aphasia, visual problems

Onset sudden

Thunderclap

Onset after age 50 years

Vascular (temporal arteritis), tumor, infection

Pattern change

Any new or changed headache pattern or quality or increase in frequency or intensity

Postural headache

Aggravation by either lying flat or standing up

Papilledema**Precipitants**

Valsalva maneuver (ie, cough, exertion)

Box 4-3 Structures sensitive or insensitive to pain**Sensitive to pain***Intracranial*

- Dura mater
- Venous sinuses and their tributaries
- Intracranial arteries (proximal portions)
- Neural structures:
 - Trigeminal nerve (V)
 - Facial nerve (VII)
 - Glossopharyngeal nerve (IX)
 - Vagus nerve (X)
 - Upper cervical nerves

Extracranial

- Carotid, vertebral, and basilar arteries
- Blood vessels within the scalp and skin
- Skin
- Mucosa
- Muscles
- Fascia
- Synovium within the TMJ
- Teeth
- Periosteum

Insensitive to pain*Intracranial*

- Brain parenchyma
- Pia mater
- Arachnoid membrane
- Ependyma
- Choroid plexus

Extracranial

- Skull
- Cervical vertebrae

Box 4-4 Differential diagnosis of acute-onset secondary headache⁵**Vascular**

- Subarachnoid hemorrhage (ICHD 6.2.2)
- Saccular aneurysm (ICHD 6.3.1)
- Arteriovenous malformation (ICHD 6.3.2)
- Carotid or vertebral artery dissection (ICHD 6.5.1)
- Cerebral venous thrombosis (ICHD 6.6)
- Pituitary apoplexy (ICHD 6.7.4)

Nonvascular

- Acute hypertension (ICHD 7.1)
- Benign intracranial hypertension (ICHD 7.1.1)
- Intermittent hydrocephalus (ICHD 7.1.3)
- Intracranial infection (ICHD 9.1)
- Pheochromocytoma (ICHD 10.3.1)
- Acute glaucoma (ICHD 11.3.1)
- Acute mountain sickness (at altitude)
- Acute optic neuritis

angiography and magnetic resonance imaging (MRI) may be considered, noting the incidence of incidental intracranial aneurysm to be 3% of the general population.⁵ The differential diagnosis of a thunderclap headache is summarized in Box 4-4.

Onset after age 50 years

In patients older than 50 years, new-onset and/or progressive or changing headaches are worrisome and warrant evaluation. Migraines may begin at any age, but the vast majority of individuals will have onset by the time they are 30 years old. Headache in older patients with no prior history is inherently concerning and likely has a secondary cause. Contingent on the findings from the history and physical examination, the clinician should consider

an MRI study of the brain with and without contrast. In addition, hematologic tests may be necessary, such as erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) to rule out GCA, complete blood count to rule out anemia and blood dyscrasia, free thyroxine and thyroid-stimulating hormone levels to rule out thyroid disease, and a Lyme titer to rule out Lyme disease.

Pattern change

When patients experience their first headache or the worst headache of their life, or if there is a change in attack frequency, severity, associated symptoms, or quality, the clinician should review the case for other red flags and seriously consider further investigations. Any migraine can be considered the worst headache of a person's life, but patients with migraine may also develop secondary headaches. Chronic and recurrent headaches typically present with similar features over time, but patients should be encouraged to note and report changes in headache pattern. Progressively worsening headaches at any age need to be carefully assessed.

Postural headache

Migraines characteristically improve with lying down and are aggravated by routine physical activity. If the headaches are precipitated by sitting upright or standing, with improvement on lying down, this can be a sign of a low-pressure headache due to a cerebrospinal fluid (CSF) leak. In contrast, headaches on lying down can be caused by increased intracranial pressure related to an intracranial mass, cerebral venous thrombosis, meningeal process, or idiopathic intracranial hypertension. Headaches presenting only on awakening may be associated with obstructive sleep apnea, substance overuse or withdrawal, brain tumor, or oral parafunctional habits such as bruxism. Headaches that actually awaken

a patient from his or her usual sleep pattern need to be investigated further to rule out increased intracranial pressure, although other disorders such as cluster headache, migraine, cervicogenic headache, and GCA should also be considered.

Papilledema

Papilledema is one of the most important neurologic signs to identify in patients with headaches because it immediately directs the examiner toward evaluation of secondary causes. Papilledema indicates swelling of the optic nerve head, which can arise in the context of elevated intracranial pressure.

Precipitants

Headaches precipitated by a cough, a sneeze, straining, or exertion, although possibly benign, warrant an MRI scan of the brain to exclude an intracranial structural lesion such as a tumor or Arnold-Chiari malformation. This clinical history should be carefully distinguished from headaches that are only worsened by a Valsalva maneuver, which are typically benign.

Headache Attributed to Cranial or Cervical Vascular Disorder (ICHD 6)

Ischemic stroke (ICHD 6.1; *ICD-10* I63) or transient ischemic attack (ICHD 6.1; *ICD-10* G45)

Headache associated with acute ischemic cerebrovascular disease (ICHD 6.1) is well recognized but poorly understood.^{6,7} The etiology should be considered based on the accompanying neurologic deficits that present in an acute fashion, often in a person older than 50 years, and seem temporally related to the head pain. The headache is typically continuous with tension-type features and is only rarely

thunderclap in progression.⁷ Posterior circulation dysfunction in the vertebral and basilar artery distribution is more likely than anterior circulation disease to cause headache. Neurologic deficits reflect the region of the brain affected and may include vision loss, diplopia, weakness, sensory loss, aphasia, and ataxia. Transient ischemic attacks present in a similar fashion, but the deficits resolve within 24 hours, frequently within 20 minutes. Signs or symptoms consistent with cerebral ischemia warrant referral to the emergency room.

Headache secondary to ischemic stroke typically affects older individuals with risk factors such as hypertension, atrial fibrillation, and tobacco use. However, stroke can occur at any age. Patients presenting with stroke should undergo a CT scan of the head to rule out an intracranial hemorrhage. An MRI study with diffusion-weighted imaging has a higher sensitivity and specificity for detection of acute cerebral ischemia and tissue damage. The differential diagnosis for a patient with headache and neurologic symptoms must include migraine. However, an older migraineur who develops a headache with new neurologic signs or symptoms should be considered to have vascular compromise until proven otherwise. Treatment for the headache must be individualized, but this pain typically lasts a few days at most and vasoactive drugs are contraindicated.⁷

Traumatic and nontraumatic intracranial hemorrhage

Headache secondary to traumatic intracranial hematoma may be due to an epidural hematoma (ICHD 5.5.1; *ICD-10* S06.4) or a subdural hematoma (ICHD 5.5.2; *ICD-10* S06.5). Headache secondary to nontraumatic intracranial hematoma may be due to an intracerebral hemorrhage (ICHD 6.2.1; *ICD-10* I61) or an SAH (ICHD 6.2.2; *ICD-10* I60).⁶ Similar to pain associated with ischemia, pain stemming from hemorrhage is best diagnosed according to its accompanying symptoms.

Traumatic intracranial hematoma (ICHD 5.5, ICD-10 S06)

An epidural hematoma (ICHD 5.5.1; ICD-10 S06.4) is most often caused by severe blunt trauma to the skull and rupture of the middle meningeal artery.⁶ A *lucid interval* may be observed wherein the patient appears to mostly recover after head trauma only to become somnolent and then comatose shortly thereafter. This lucid interval is more the exception than the rule; more frequently, patients will continue to have severe pain followed by a change in cognition. Rapid surgical drainage of epidural hematomas is necessary to prevent mortality, necessitating a high index of suspicion after head trauma.

A subdural hematoma (ICHD 5.5.2; ICD-10 S06.5) may present acutely, subacutely, or even with chronic symptoms.⁶ The subdural space fills with blood after the bridging veins coursing through it rupture, usually after a fall or other type of head trauma. Older patients and alcoholics are at greater risk because they are more likely to have gait instability and their bridging veins are not as resistant to trauma. There is often a history of minimal trauma, like a minor motor vehicle accident without direct head trauma in which neurologic symptoms begin several hours or even days later. Patients on anticoagulation therapy and those taking frequent aspirin or nonsteroidal anti-inflammatory drugs (NSAIDs) are particularly at risk, even with seemingly minimal head trauma. Pain is not always the chief complaint. Symptoms may include any neurologic deficit, such as gait disturbance, personality change, somnolence, visual disturbances, or focal changes such as hemiparesis, hemisensory changes, and visual field defects. Surgical evacuation of the hematoma may be necessary, but careful observation of a small subdural hematoma without brain shift or pressure can be an effective treatment.

Nontraumatic intracranial hemorrhage (ICHD 6.2, ICD-10 I62)

Head pain associated with a nontraumatic intracerebral hemorrhage (ICHD 6.2.1; ICD-10 I61) most typically presents with acute neurologic deficits.⁶ *Intracerebral hematoma* refers to a hematoma within the brain parenchyma and may be caused by many etiologies (eg, hypertension, neoplasm, arteriovenous malformations). If it is large enough, this hematoma can extend into a ventricle. Of course, this may quickly lead to coma or even death contingent upon the cause and the volume of blood, which produces concomitant destruction of cerebral tissue, mass effect, and possibly herniation of the mesial temporal lobe, compressing the third cranial nerve.

Headache due to an SAH (ICHD 6.2.2; ICD-10 I60) is fairly characteristic.⁵ Patients with an SAH typically present with a very sudden-onset thunderclap headache. This pattern of headache reaches its maximal intensity in less than 1 minute, often within seconds. Asking whether a patient was experiencing “the worst headache of their life” is not as useful as asking questions that get at the sudden nature of the onset with dramatic rise to peak pain within seconds. In a series of patients eventually diagnosed with SAH, headache intensity reached its peak between 1 to 5 minutes in almost 20% of the cohort.⁸ SAHs commonly present with nausea and vomiting, a stiff neck, or rapid loss of consciousness. A ruptured saccular aneurysm is the most common cause of a spontaneous SAH. Whenever an SAH is suspected, the patient should be immediately sent to an emergency room, preferably by ambulance, where a detailed neurologic examination can be performed followed by a head CT scan. In the case of a thunderclap headache with a normal head CT, a lumbar puncture is warranted to rule out microscopic evidence of bleeding or xanthochromia (which may take several hours to develop) as well as to rule out other worrisome etiologies of sudden headache, like

meningitis. In addition, further testing such as MRI studies could be considered to evaluate for other potential etiologies.⁵ Key aspects of treatment include maintaining hemodynamic stability, neurosurgical consultation for either aneurysmal clipping or endovascular coiling, and treatment for avoidance of vasospasm.⁵

Unruptured vascular malformation (ICHD 6.3)

Unruptured vascular malformations include saccular aneurysms (ICHD 6.3.1; *ICD-10* Q28.3), arteriovenous malformations (ICHD 6.3.2; *ICD-10* Q28.2), dural arteriovenous fistulae (ICHD 6.3.3; *ICD-10* I67.1), and venous and cavernous angiomas (ICHD 6.3.4; *ICD-10* D18.0).⁶ These headaches may be silent until they rupture, or they may present with non-specific head pain. Patients can present at any age, and some may complain of pulsatile tinnitus, though this is not always a sign of ominous pathology. A family history is often positive. A magnetic resonance angiogram (MRA) or computed tomography angiography (CTA) may be helpful in the diagnostic process.

Saccular aneurysms may be incidental and asymptomatic, and they are present in 3% of the population.⁵ Therefore, assigning causality to these entities as a source for headache can risk inappropriate intervention. Screening with CTA or MRA should be offered to patients who have at least two family members with known aneurysm or prior SAH.⁹ Aneurysms that are small (< 7 mm) and in the anterior circulation are unlikely to rupture, whereas large, posterior circulation aneurysms involve a substantially greater risk.⁹ While patients may experience improvements in headache following repair, a subset of patients will have headaches that worsen following aneurysmal repair. This is especially likely in patients with severe headache and trait anxiety.¹⁰

Arteritis (ICHD 6.4, *ICD-10* M31)

Arteritis typically presents with systemic symptoms and/or neurologic deficits, but at times it may present initially with throbbing unilateral pain in the temple. The pain associated with GCA or temporal arteritis (ICHD 6.4.1; *ICD-10* M31.6) is fairly distinct from that of other arteritides.¹¹ GCA is an inflammatory vasculitis that involves the temporal artery as well as others and may rapidly lead to blindness secondary to granulomatous occlusion of the carotid artery vasculature. GCA should be suspected and ruled out in all individuals, especially women over the age of 50 years who present with a new headache and associated visual changes and/or jaw claudication. Patients may complain of pain on combing their hair as a consequence of allodynia of the scalp. Patients with GCA may have polymyalgia rheumatica that causes pain, stiffness, and weakness in the neck, shoulders, and proximal arms and legs. On examination, they may have an enlarged, tender temporal artery. Laboratory investigations should include an ESR and CRP test. Temporal artery biopsy may often be required for diagnosing GCA, but high doses of corticosteroids should be initiated as soon as possible, even prior to the biopsy, to avoid permanent loss of vision.¹¹ An adequate biopsy sample is necessary for diagnosis due to the histopathologic occurrence of skip lesions, where pathologic changes may be interspersed with segments that appear normal.¹¹ GCA can usually be distinguished from temporomandibular disorders by palpation of enlarged, tender temporal arteries with reduced pulsatility, an abnormal fundoscopic examination, and an elevated ESR and CRP. The level of ESR and CRP values should always be interpreted in the context of the practitioner's pretest probability, as GCA may even occur in the presence of normal systemic inflammatory markers.¹¹

Cervical carotid or vertebral artery disorder (ICHD 6.5)

Carotid (*ICD-10* I77.71) or vertebral artery dissection (*ICD-10* I77.74) presents with ipsilateral focal pain in the neck, face, or head, frequently associated with neurologic symptoms including transient ischemic attacks or stroke.⁶ The pain may be associated with pulsatile tinnitus or Horner syndrome because of the intimate association of sympathetic fibers with the internal carotid artery.^{12,13} This is an important cause of stroke in younger patients but can happen at any age. Patients may be able to recall a specific activity that may have provoked a traumatic dissection like blunt trauma to the neck, riding a roller coaster, surfing, chiropractic manipulation, dancing, or anything that twists their neck. However, there is often no history of injury, suggesting a spontaneous dissection that could be associated with preceding arterial damage, such as fibromuscular dysplasia or even just a history of migraine. Blood dissects between the medial and subintimal layers of an artery, which may then fill to form a pseudoaneurysm and cause ischemia by either partial occlusion of the lumen or embolic debris.

Besides checking for new pupillary asymmetry, audible bruits should be sought in the neck or over the orbit or temporal bone, which may indicate the presence of turbulent blood flow. If dissection is suspected, patients should immediately be referred to either a neurologist or a neurosurgeon, who will likely investigate this further with extracranial duplex ultrasound vascular scanning, MRI, and MRA or CTA of the cervical vessels.^{5,6} Arterial dissection is easily missed unless the clinician is thinking of it. Clinical trial data indicates no difference in outcomes among patients treated with either antiplatelet or anticoagulation therapy.¹⁴

Idiopathic carotidynia is usually a nonworrisome cause of focal arterial tenderness. In recent years, this diagnosis has fallen out of favor due to a lack of specificity, and a critical review

of the literature revealed that it is not a valid single pathologic entity.⁶ Carotidynia may have a viral etiology. Other causes include but are not limited to carotid artery dissection, post-carotid endarterectomy, aneurysm, GCA, and fibromuscular dysplasia.⁶ Therefore, management should include referral to a neurologist.

Cerebral venous thrombosis (ICHD 6.6)

Venous thrombosis (ICHD 6.6; *ICD-10* I63.6) may present with acute severe pain or subacute to chronic pain.⁶ Patients may complain of a severe new headache associated with visual disturbances, signs of increased intracranial pressure (eg, nausea, vomiting, or papilledema), seizures, or frank neurologic deficits. Headache may also be the sole manifestation.¹⁵ Venous congestion can produce ischemic or hemorrhagic cerebral infarction. Predisposing factors include dehydration, oral contraceptive use, postpartum state, prothrombotic blood dyscrasia, neoplastic conditions, mild to moderate head trauma, and local infection.¹⁶ Patients suspected of having a venous thrombosis should be immediately referred to a neurologist or a neurosurgeon, who will likely investigate further by obtaining an MRI scan with MR venography or CT scan with CT venography. Treatment may consist of modifying the predisposing factors and at least 6 months of anticoagulation therapy.¹⁶

Other intracranial arterial disorder (ICHD 6.7)

Reversible cerebral vasoconstriction syndrome (RCVS) (ICHD 6.7.3) has a pathognomonic presentation of recurrent thunderclap headache.⁵ The syndrome is frequently precipitated by substance or medication exposures, most often selective serotonin reuptake inhibitors, stimulants, or marijuana. RCVS may occur postpartum as well. The syndrome may be complicated by stroke or hemorrhage, including cortical SAH, all leading to significant

morbidity. RCVS may be diagnosed with an MRA, CTA, or conventional angiography, and it is treated with calcium channel blockers to reverse arterial vasospasm. The offending agent should be discontinued promptly. CSF evaluation is often pursued to exclude angiitis (vasculitis), which may have similar findings on vascular imaging of arterial beading.

Genetic vasculopathy (ICHD 6.8)

Cerebral autosomal dominant arteriopathy with subcortical infarcts (CADASIL) (ICHD 6.8.1) is a rare genetic cause of stroke and dementia in young adults.¹⁷ There is a strong association with migraine with aura, which may be a presenting early feature. Neuroimaging with MRI will demonstrate characteristic white matter hyperintensities involving the anterior temporal poles and external capsule. The diagnosis can be confirmed with electron microscopy of a skin biopsy and/or genetic testing for the *Notch3* mutations.

Mitochondrial encephalopathy, lactic acidosis, and stroke-like episodes (MELAS) (ICHD 6.8.2) is a rare heterogenous disorder that may present with migraine, seizures, vomiting, and/or focal cortical deficits (eg, visual field loss). As implied by the name, lactic acidosis may be seen in the blood or elevated in the brain as measured using magnetic resonance spectroscopy. The diagnosis may be confirmed with muscle biopsy or genetic testing. As with other mitochondrial disorders, the transmission is maternal in origin.

Pituitary apoplexy (ICHD 6.9, ICD-10 E23.6)

Pituitary apoplexy refers to a stroke of the pituitary gland, often with a preexisting pituitary tumor. The disorder is almost always accompanied by acute headache and is frequently associated with visual field deficits and diplopia. The diagnosis can be confirmed with a CT or MRI scan. Patients may require surgery or may be managed conservatively. Systemic compli-

cations like hypotension can occur as a result of associated endocrine deficiencies requiring hormone replacement. Because of the high mortality rate, prompt recognition and treatment are critical.¹⁸

Headache Attributed to Nonvascular Intracranial Disorders (ICHD 7)

Increased CSF pressure (ICHD 7.1)

Increased intracranial pressure (ICHD 7.1; *ICD-10* G93.2) may yield a nonspecific headache involving any region of the head.¹⁹ Patients may have a mass that exerts pressure or have a process that impairs the normal circulation and egress of CSF, such as venous thrombosis or meningitis. This headache typically worsens with a Valsalva maneuver or recumbence and may be associated with nausea/vomiting, visual problems, and neurologic deficits.¹⁹ Examiners should look for extraocular movement abnormalities, especially diplopia, and evidence of early papilledema. Idiopathic intracranial hypertension (*ICD-10* G93.2) (which used to be called *pseudotumor cerebri*) occurs most often in young, obese females.¹⁹ Oral contraceptive pills and certain other medications like tetracycline may also be risk factors. Typically, this condition produces a holocephalic daily headache with intermittent visual disturbances and pulsatile tinnitus. Neuroimaging (ie, MRI) should be unremarkable except for slit-like ventricles and sometimes stenosis of both transverse sinuses, especially apparent on MR venography. Examination may reveal early or frank papilledema and/or bilateral abducens (sixth) nerve palsy. Increased opening pressure on lumbar puncture obtained in the lateral decubitus position is usually higher than 250 mm H₂O, and this finding along with a normal MRI scan of the head confirms the diagnosis. Blindness may ensue if this syndrome is left untreated; it should therefore

be managed along with an ophthalmologist to monitor vision.¹⁹ Fortunately, the increased intracranial pressure can remit with as little as 5% weight loss. Treatment also includes the use of acetazolamide, which decreases production of CSF.^{20,21} Some patients may require multiple lumbar punctures to lower CSF pressure, optic nerve sheath fenestration for relief of papilledema, or ventriculoperitoneal shunting of CSF to reduce headaches and prevent further visual loss.¹⁹

Low CSF pressure (ICHD 7.2)

Headaches due to low CSF pressure (ICHD 7.2; *ICD-10* G97.1) are classically worsened within a few minutes of standing and relieved by recumbence.²¹ They may be accompanied by neck stiffness or pain, tinnitus, hypacusia, paresthesia of the neck and arms, photophobia, or nausea. Headaches due to low CSF pressure may be iatrogenic after dural or lumbar punctures (ICHD 7.2.1; *ICD-10* G97.0), postoperative, or spontaneous (ICHD 7.2.3; *ICD-10* G97.1). Spontaneous CSF volume depletion may be associated with meningeal diverticula, weakened dura mater, or connective tissue diseases such as Marfan syndrome.²¹ The positional component usually becomes less evident over time. This form of headache is produced by traction placed on the dura mater and its pain-sensitive vasculature by the sagging brain when standing. An MRI study with intravenous gadolinium is required to reveal the classic finding of pachymeningeal enhancement of the dura and perhaps descent of the cerebellar tonsils, with flattening of the prepontine cistern and distortion of the brainstem. The headaches may resolve spontaneously or within 48 to 72 hours of treatment. Treatment may involve prolonged, complete bedrest without head elevation for 2 to 3 days, mild analgesics, caffeine or theophylline, or an epidural blood patch.²¹ The blood patch has a pain relief success rate of over 90% in iatrogenic cases.

Noninfectious inflammatory diseases (ICHD 7.3)

Headaches with inflammatory conditions include neurosarcoidosis (ICHD 7.3.1; *ICD-10* D86.8) and aseptic meningitis (ICHD 7.3.2; *ICD-10* A87.9).²² These entities cause various nonspecific symptoms whose recognition comes only with vigilant observation and detection of red flags. The only red flag that might be obvious for aseptic meningitis is a severe headache occurring during or after a viral infection. Some drugs, classically NSAIDs and intravenous immunoglobulin, can also cause aseptic meningitis. Investigations necessary for diagnosis often include an MRI scan of the head, CSF examination, and blood studies.

Intracranial neoplasia (ICHD 7.4)

Intracranial neoplasms are accompanied by headaches in approximately 50% of patients during the course of the illness and are one of the primary presenting symptoms in approximately 20% of these cases.²³ Patients presenting with headache frequently worry about having a brain tumor, but headache is very rarely the sole symptom (one case series reported 2%).²³ More often, the patient presents with focal neurologic symptoms or a seizure. Headaches may be attributed to increased intracranial pressure or hydrocephalus caused by the neoplasm (ICHD 7.4.1), to the pressure from the neoplasm itself (ICHD 7.4.2), or to carcinomatous meningitis (ICHD 7.4.3; *ICD-10* C79.32).²³ The earlier concept that headaches present upon awakening were often caused by a brain tumor has been largely abandoned. The time course is most typically subacute to chronic, and there will usually be other symptoms that make the diagnosis suspect: weight loss, personality changes, seizures, and/or neurologic deficits such as focal weakness or numbness, trouble walking, or visual disturbances. Head pain brought on acutely by coughing or a Valsalva maneuver is

usually benign but can, in rare cases, be due to a tumor causing increased intracranial pressure. Occasionally, neoplastic processes may intermittently occlude normal CSF flow, producing a ball-valve mechanism that manifests as posture-dependent symptoms. If a patient presents with a new headache with some of these symptoms, a neurologic consultation and a contrast-enhanced MRI study of the head are warranted. There is an association between headache and pituitary tumors where the headache most often resembles migraine, but it can also present with more unusual phenotypes, such as primary stabbing headache, cluster headache, or short-lasting unilateral neuralgiform headache attacks with conjunctival injection and tearing (SUNCT).²⁴

Chiari malformation type I (ICHD 7.7; ICD-10 Q07.0)

Herniation of the cerebellar tonsils 3 to 5 mm below the foramen magnum or caudally to the C2 level represents a structural malformation of the brainstem and dura known as the *Arnold-Chiari malformation*.²⁵ In a patient presenting with headache, it should be noted that this radiographic appearance can be mimicked by both intracranial hypertension and hypotension, where a descent of the base of the brain may occur.²¹ This syndrome is commonly delineated by the type of abnormality and may include hydrocephalus, myelomeningocele, syringomyelia, other spinal cord cavitations (ie, syrinx), and distortions of the components of the middle and posterior fossa.²⁵ There may be flattening of the pons and effacement of the prepontine cistern with kinking of the brainstem. The syndrome can be associated with headaches, hemifacial spasm, coughing with or without symptoms of central sleep apnea, the inability to speak, dysphagia, and nystagmus.²⁵ Arnold-Chiari malformation may cause traction or compression of one or more cranial nerves, which requires a definitive neurologic assessment as well as an MRI study. More

serious complications occur if the medulla or cervical spinal cord is compressed, which could lead to weakness of the limbs and hyperreflexia with extensor plantar responses (positive Babinski reflex). Milder cases without neurologic symptoms should be followed conservatively. Headache also is not an indication for surgery; surgical decompression is most often required if there are neurologic signs. This abnormality can exist in children as well as in adults.²⁵

Headache Attributed to Infection (ICHD 9)

Headaches may be attributed to intracranial infections, including bacterial meningitis (infection of the meninges) (ICHD 9.1.1; *ICD-10* G00.9), lymphocytic meningitis (ICHD 9.1.2; *ICD-10* G03.9), encephalitis (infection of the brain parenchyma) (ICHD 9.1.3; *ICD-10* G04.90), brain abscess (localized walled-off infection of the brain substance) (ICHD 9.1.4; *ICD-10* G06.0), and subdural empyema (infection localized to the subdural space) (ICHD 9.1.5; *ICD-10* G06.2).²² The headache is most commonly holocephalic in association with fever, arthralgia, stiff neck, photophobia, nausea and/or vomiting, altered consciousness, and confusion.²² These symptoms may develop over minutes to hours, and the condition of the patient may deteriorate rapidly. Patients with encephalitis are often drowsy, confused, and disoriented on examination. Those with meningitis have stiff necks that cannot be flexed and occasionally positive Kernig and Brudzinski signs.²⁶ Progression of symptoms over hours may be the most important clue because fever or meningismus may be absent, especially in the very young, old, or immunocompromised. Patients may die within hours if not properly treated. Interestingly, many brain abscesses can present as a space-occupying mass with neurologic findings related to the mass but without any meningeal irritation, abnormalities

on CSF testing, or fever. Scans show only an avascular mass, often with a ring around its edge. Meningococcal meningitis is deadly if not treated within hours. Any patients with a rash, fever, headache, stiff neck, and vomiting should have an emergency diagnostic lumbar puncture after a CT or MRI scan and be treated pending the CSF results.

Herpes simplex is the most common cause of nonepidemic viral encephalitis and typically presents with acute headache, fever, cognitive changes, drowsiness, and focal findings such as hemiparesis and seizures. Early antiviral therapy greatly reduces permanent neurologic sequelae. Patients with an abscess or subdural empyema present similarly to those with severe meningitis, with headache, fever, malaise, and possibly signs of increased intracranial pressure. Certain fungal meningitides can be difficult to diagnose because they present with no fever and spinal fluid appearing normal, requiring special CSF antigen testing, staining, and cultures. Sometimes a history of the individual's geographic location and whom they had been in contact with can be revealing.

The diagnostic procedures include blood cultures and complete examination of CSF, both with cultures and gram staining, polymerase chain reaction, and imaging techniques including CT and MRI scans. The clinician should be aware that patients with AIDS may suffer head, neck, and orofacial pain from numerous infectious etiologies, including any of those discussed previously. In rare cases, dental and surgical procedures can be complicated by central nervous system infection.

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5

Primary Headache Disorders

Key Points

- ◇ Clinicians who treat oral and facial pains should become well versed in primary headache disorders.
- ◇ Clinicians should use the most current version of the International Classification of Headache Disorders to accurately diagnose primary headache disorders.
- ◇ Clinicians need to be familiar with the most up-to-date, evidence-based care of primary headache disorders.
- ◇ If they are in doubt as to a definitive diagnosis and appropriate therapy, clinicians should consider referral to a health care practitioner who is knowledgeable in the diagnosis and management of headache disorders.

P *primary headaches* are disorders unto themselves and are not attributed to any other cause or condition. The criteria for diagnosis include the descriptors and clinical presentation as well as the exclusion of other disorders. Primary headaches account for approximately 90% of headache cases in patients presenting to primary care.¹ The International Classification of Headache Disorders, third edition (beta version) (ICHD) classifies primary headache disorders into four categories²:

1. Migraine
2. Tension-type headache (TTH)
3. Trigeminal autonomic cephalalgias (TACs)
4. Other primary headache disorders

A complete listing of primary headache disorders can be found at the ICHD website. This chapter focuses on the most common primary headache presentations: migraine, TTH, and select TACs. Each discussed disorder includes the ICHD codes established by the Headache Classification Committee of the International Headache Society as well as those described in the International Classification of Diseases, Tenth Edition (ICD-10).

Migraine (ICHD 1.x.x, ICD-10 G43.xxx)

Clinical presentation and diagnosis

Migraine is reported by the World Health Organization to be the third most prevalent and the seventh most disabling illness in the world.^{3,4} It is considered a familial neurobiologic disorder of the central nervous system (CNS) characterized by increased brain sensitivity and mostly episodic pain presentation.⁵ Migraine typically presents with recurrent throbbing and mostly unilateral painful attacks of moderate to severe intensity lasting 4 to 72 hours untreated or undertreated. In children and adolescents (aged under 18 years), the attacks may last 2 to 72 hours. The head pain is associated with certain characteristic features such as nausea, phonophobia, and photophobia and is typically aggravated by activity. One-third of migraineurs will experience transient neurologic symptoms such as visual disturbance or other sensory phenomena prior to the onset of the headache event. This is known as *aura*.⁶ Some individuals will experience premonitory symptoms such as tiredness, yawning, sensory hypersensitivity, increased food cravings, thirst, and polyuria that tend to be highly predictive of the attack. These symptoms may occur anywhere from 2 to 24 hours prior to the attack and are highly suggestive of CNS etiology.^{2,7} The ICHD criteria may be used to confirm the diagnosis of migraine when the described criteria are met and

after organic disease is excluded. If a patient meets the criteria for more than one subtype of migraine, all subtypes should be diagnosed and coded. The ICHD criteria for migraine are as follows: (1) Patients need to have experienced at least five previous and similar attacks, fulfilling the following criteria: (a) two of the following pain characteristics must be present: unilateral pain, pulsatile quality, moderate to severe intensity, and/or aggravation by or causing avoidance of routine physical activity; and (b) the attack must be accompanied by nausea (and/or vomiting) or photophobia and phonophobia. (2) The headache may not be better described by another ICHD diagnosis.

Migraine attacks may occur without aura (ICHD 1.1, ICD-10 G43.0) or with aura (ICHD 1.2, ICD-10 G43.1). *Aura* is the presence of fully reversible focal neurologic symptoms that develop gradually over 5 to 20 minutes and last no more than 1 hour. Aura may also occur in the absence of a typical migraine headache (ICHD 1.2.1.2, ICD-10 G43.104). Aura often takes the form of positive visual phenomena that move across the visual field over minutes, migrating paresthesias, or dysphasic speech. The ICHD criteria for migraine with aura are as follows²:

At least two attacks fulfilling the following criteria: (1) One or more of the following fully reversible aura symptoms: visual, sensory, speech and/or language, motor, brainstem, and/or retinal. (2) At least two of the following four characteristics: at least one aura symptom spreads gradually over ≥ 5 minutes, and/or two or more symptoms occur in succession; each individual aura symptom lasts 5 to 60 minutes; at least one aura symptom is unilateral; the aura is accompanied, or followed within 60 minutes, by headache.

Individuals who meet criteria for migraine without aura but have had fewer than five attacks should be coded as probable migraine without aura (ICHD 1.5.1, ICD-10 G43.83), and individuals who meet criteria for migraine with aura that have had only one attack should be

coded as probable migraine with aura (ICHD 1.5.2, *ICD-10* G43.83).

If migraine occurs on more than 15 days per month for at least 3 months and has the features of migraine headache on at least 8 days of the month, it is classified as *chronic migraine* (ICHD 1.3, *ICD-10* G43.3). A debilitating migraine persisting for more than 72 hours in succession is classified as *status migrainosus* (ICHD 1.4.1, *ICD-10* G43.2). Complications of migraines are rare but may include persistent aura without infarction (ICHD 1.4.2, *ICD-10* G43.3), migrainous infarct (ICHD 1.4.3, *ICD-10* G43.3), and migraine aura-triggered seizure (ICHD 1.4.4, *ICD-10* G43.3).

Epidemiology

Migraine is a common condition affecting approximately 12% of the population in Western countries.⁸ In the United States, the prevalence of migraine is 18% in females and 6% in males.⁸ It has been reported that greater than 90% of patients presenting with a stable, recurring, severe headache probably have migraine.⁹ According to a recent Global Burden of Disease report, migraine is now the sixth highest cause of disability worldwide.^{10,11} Migraine is considered to be the most disabling of all headache disorders.¹² In boys, migraine with aura will peak at age 5 years while migraine without aura tends to peak at age 10 to 11 years.¹³ Migraine peaks later in girls than in boys, with migraine with aura occurring at age 12 to 13 years and migraine without aura at age 14 to 17 years.¹³ New onset of migraine is an uncommon finding in men in their third decade. The highest prevalence of migraine occurs in ages 30 to 39 years and is at its lowest after the age of 60. The prevalence is higher for both men and women in whites than in blacks.

Because migraine usually affects people during their most productive years, it is a major burden to the patient and society. Not only does it affect the patient's quality of life by impairing his or her ability to participate in family, social,

and recreational activities, but it also affects society in terms of direct costs (eg, medical care) and indirect costs (eg, absenteeism and reduced effectiveness at work). It is estimated that 23 million US residents have severe migraines.¹⁴ Twenty-five percent of women experience four or more severe attacks per month, 35% experience one to three severe attacks per month, and 40% experience one or fewer than one severe attack per month. The study also found that more than 85% of women and more than 82% of men with severe migraine had some migraine-related disability.

Pathogenesis

Many mechanisms and theories explaining the causes of migraine have been proposed, though the full picture is still unknown. The extensive variability in the clinical presentation of the disorder provides an even greater challenge to the identification of pathoetiologic mechanisms. Migraine appears dependent on activation of the trigeminovascular system.¹⁵ Activation of the receptors on the dura and associated vessels, activation of the thalamocortical pathways, and an inhibition of the descending cortical pain-controlling pathway all apparently contribute to the migraine event. The cyclical and lifetime fluctuations in female sex hormone concentrations might explain why migraine is so much more prevalent in women and why migraine activity may vary so substantially throughout life. Migraine has traditionally been believed to be a genetic disorder due to the common occurrence among family members. It has been reported that at least 50% of migraine patients have a first-degree relative who also experiences this disorder.^{16–21}

Typical migraine is believed to be polygenic, but several monogenic forms of migraine have been identified. Familial hemiplegic migraine (FHM) is a monogenic form with aura presenting as hemiparesis. To date, mutations in three different ion channels or ion pumps have been found as potential causes of FHM.⁵ In recent

genome-wide association studies, common migraine risk appears to be associated with 38 genomic loci.²² It appears that the influence on migraine is a result of the interaction of the group as a whole along with lifestyle and environmental factors, as opposed to the effect of each locus individually. While there does not appear to be much in the way of overlap of mechanisms between the monogenic or polygenic migraine subtypes, common pathways involving the development and function of neurons and synapses, vascular system development, and glutamate transport mechanisms appear to be significant for both.²³ These findings could potentially point to a more significant role of vascular dysfunction in migraine pathophysiology than previously thought. This role is further supported by the frequent occurrence of disorders that are commonly comorbid with migraine such as stroke and cardiovascular disease.^{24,25} The migraine aura correlates with the cerebral cortical event of cortical spreading depression (CSD), a slowly propagating wave of depolarization, hyperpolarization, and vascular changes. In animal models, CSD has been shown to lead to trigeminovascular activation, resulting in the release of neuropeptides, neurogenic inflammation, increased vascular permeability, and dilation of blood vessels.²⁶ Whether these vascular changes are necessary for the full expression of migraine symptoms including headache is still debated.^{27,28} Recent evidence seems to suggest that vascular events do not appear to be a necessary component of the migraine event, nor are they sufficient to induce migraine on their own.²⁹ Borsook and Burstein³⁰ suggest that activation in the nuclei of the dorsolateral pons may be partly responsible for multiple processes including facial pain and altered pain modulation. Recent functional magnetic resonance imaging (MRI) studies have shown the hypothalamus to not only be an important modulator of the premonitory aspect of the migraine event but also the migraine attack itself.³¹ More specifically, the pos-

terior portion of the hypothalamus appears to be important for the headache phase, whereas the anterior region seems to play a critical role in migraine chronification. However, given the available evidence, identifying a specific area of the brain as the migraine generator is not presently feasible.³² Multiple neurotransmitters and modulators, including serotonin, calcitonin gene-related peptide (CGRP), nitric oxide, dopamine, and glutamate, have been implicated in migraine pathophysiologic mechanisms.^{33,34} Central sensitization producing allodynia and hyperalgesia is thought to be an important clinical manifestation of migraine.³⁵

Management

In addition to pharmacotherapy, migraine management modalities should include educational interventions, lifestyle and behavioral modifications, and trigger-avoidance strategies. Pharmacologic interventions may be abortive/symptomatic or prophylactic. Patients who experience frequent severe migraine attacks often require both approaches. The decision of the most appropriate management approach should be based on type of presentation of the migraines (episodic or chronic), the level of impairment that they cause, previous management history and response, and patient preferences. Consideration should also be given to any comorbid conditions such as depression or hypertension. Abortive medications only may be used for individuals with fewer than 4 headache days per month and no impairment or those with no more than 1 headache day per month regardless of impairment.⁸ Individuals with more frequent attacks, such as those with 6 or more migraine days per month with normal functioning, 4 or more migraine days with some impairment, or 3 or more migraine days with severe impairment, should be considered for management with prophylactic medications.⁸ If there is a comorbid illness, a prophylactic agent that can treat both conditions should be used when

Box 5-1 Common medications used to abort migraine attacks³⁸**Selective**

- Selective serotonin receptor agonists (triptans)
- Dihydroergotamine

Nonselective

- Acetaminophen, aspirin plus caffeine
- Aspirin
- Butorphanol
- Ibuprofen
- Naproxen sodium
- Diclofenac potassium

possible, and agents that might aggravate a comorbid illness should be avoided. Nonpharmacologic methods such as biofeedback, relaxation techniques, acupuncture, and other behavioral interventions can be used as adjunctive therapy.³⁶

Medications typically used for acute migraine management include selective serotonin receptor (5-HT_{1B/D}) agonists, analgesics, nonsteroidal anti-inflammatory drugs (NSAIDs), dopamine-antagonistic antiemetics, ergot alkaloids, and corticosteroids. Opioid analgesics play a limited role in management, partly due to the enhanced risks of medication-overuse headache and opioid-induced hyperalgesia.³⁷ Pharmacologic agents with evidence-based support of statistical and clinical benefit, according to the American Academy of Neurology, are listed in Box 5-1 and should be given as first-line management.³⁸ Prophylactic medications include a broad range of agents.^{39,40} The recently published US Headache Consortium Guidelines recommended evidence-based pharmacologic management for migraine prevention in adults based on a structured review process of published studies from June 1999 to May 2009 (Box 5-2).⁴¹ Anticonvulsants (eg, di-

Box 5-2 Medications used for the prevention of migraine attacks^{41,42}**Established as effective**

- Divalproex/sodium valproate*
- Metoprolol
- Onabotulinum toxin A[†]
- Petasites (butterbur)
- Propranolol*
- Timolol*
- Topiramate*

Probably effective

- Amitriptyline
- Atenolol
- Fenoprofen
- Feverfew
- Histamine
- Ibuprofen
- Ketoprofen
- Magnesium
- Nadolol
- Naproxen/naproxen sodium
- Riboflavin
- Venlafaxine

Possibly effective

- Candesartan
- Carbamazepine
- Clonidine
- Coenzyme Q-10
- Cyproheptadine
- Guanfacine
- Flurbiprofen
- Lisinopril
- Nebivolol
- Mefenamic acid
- Pindolol

*FDA-approved for episodic migraine.

[†]FDA-approved for chronic migraine.

valproex, topiramate) and β -blockers (eg, metoprolol, propranolol, timolol) have the strongest evidence of benefit for migraine prevention. These medications are started at low doses and gradually titrated to the desired effect to

minimize side effects and arrive at the minimal dose necessary for therapeutic effect. In more refractory cases, polypharmacy may be necessary. While a number of NSAIDs are included in the practice guidelines as effective for the prevention of episodic migraine, caution must be exercised about daily use because analgesic overuse can induce chronic daily headache.⁴² Botulinum toxin type A has been approved by the US Food and Drug Administration (FDA) for the preventive management of chronic migraine, in which headaches occur at least 15 days per month and at least 4 hours per day.⁴³ For the management of menstrual-related migraine, perimenstrual use of frovatriptan has been recommended.⁴¹ Naratriptan and zolmitriptan have been classified as “probably effective” for this type of migraine presentation.⁴² Emerging abortive and prophylactic management include selective 5-HT_{1F} agonists, CGRP receptor antagonists, nitric oxide synthase inhibitors, and glutamate receptor antagonists.⁴⁴

In many cases, patients are able to identify factors that seem to precipitate the onset of a migraine attack. Strategies to identify and cope with or avoid these triggers often proves helpful for these individuals.⁴⁵ Some common triggers are environmental factors, including light, noise, allergens, and barometric changes; behavioral factors, such as emotional stress, missing meals, or getting too much or too little sleep; and food/beverage items, such as caffeine, aspartame, monosodium glutamate, nitrates, and nitrites.⁴⁶

Tension-Type Headache (ICHD 2.x.x; ICD-10 G44.2xx)

Clinical presentation and diagnosis

TTH is described as a dull ache or a nonpulsating pain of mild to moderate intensity often manifesting as tightness, pressure, or soreness in a bandlike distribution as if the patient were wearing a hat. The pain location is not

specific, though it is often bilateral and may extend into the neck. Temporalis and masseter muscle involvement may be present, and mastication may be affected in some patients. TTH is not accompanied by nausea or vomiting, nor is it aggravated by routine physical activity, but it may be associated with sensitivity to either light or noise.² The headaches may last from 30 minutes to 7 days. TTHs are classified as *infrequent episodic* (ICHD 2.1, ICD-10 G44.2) if they occur on fewer than 1 day per month (fewer than 12 days per year) and *frequent episodic* (ICHD 2.2, ICD-10 G44.2) if they occur on more than 1 day per month but fewer than 15 days per month for at least 3 months. *Chronic TTH* (ICHD 2.3, ICD-10 G44.2) evolves from episodic TTH and is diagnosed when headaches occur daily or more often than 15 days per month for at least 3 months. The classification categories are typically subdivided and coded according to the presence or absence of pericranial tenderness as assessed by manual palpation. In contrast, if a new-onset daily or unremitting headache with tension-type characteristics develops, the headache is classified as *new daily persistent headache* (ICHD 4.10, ICD-10 G44.52). Sensitivity to light and/or noise and mild nausea may be present with these types of headaches. There may be difficulty distinguishing between chronic migraine and chronic TTH, and these disorders may be present simultaneously.

Epidemiology

TTH is the most common of all primary headaches.⁴⁷ In a cross-sectional population study of 740 adult subjects, 74% had experienced TTH within the previous year, while 31% of the same population had experienced TTH for more than 14 days during the previous year.⁴⁸ In another report, the 1-year prevalence rate for TTH was 63% in men and 86% in women.⁴⁹ The onset of TTH is usually between 25 and 30 years of age. In both men and women, the prevalence will peak between the ages of 30

and 39 years and then decline with increasing age.^{49–51}

Pathogenesis

For many years, it was thought that TTH was directly related to muscle tension and was therefore referred to as a *muscle contraction* or a *muscle tension headache*. Muscle tenderness may be present in some individuals; however, increased levels of electromyographic activity are not often associated with TTH.^{52,53} Electromyography has revealed an increased activity in response to emotional stressors in patients as compared with controls.^{54,55} It has been suggested that this increase in electromyographic-detected activity may not be the cause of the pain but rather a response to it. Ultimately, it has been determined that the finding of a slight increase in muscle activity noted in patients on their headache-free days would seem to contradict the hypothesis that TTH is directly related to an increase in muscle tension.⁵⁶ Emotional stress, anxiety, and depression appear to play a significant role in TTH.^{57–60}

A very controversial boundary exists between migraine and TTH. Some experts regard these disorders as distinct entities, while others see them at opposite ends of a continuum, varying in severity and features but sharing a common pathogenesis.^{61,62} Voxel-weighted morphometric MRI scans of patients with chronic TTH have demonstrated reduced gray matter density within structures previously implicated in pain processing (eg, pons and cingulate, insular, and orbitofrontal cortices) that correlates with disease duration in years.⁶³ Such changes may in fact be the consequence of central sensitization.⁶⁴ Several studies have provided evidence for spinal and supraspinal sensitization in TTH patients.^{65–67} Others have suggested impairment of pain-inhibitory and modulatory mechanisms in TTH subjects.^{68–70} To date, the specific pathophysiologic mechanisms involved in TTH are yet to be fully described.

Management

Most individuals with TTH tend to self-medicate with over-the-counter analgesics. In a community-based telephone survey of frequent headache sufferers, the majority reported using acetaminophen (56%) and aspirin (15%).⁷¹ Only 1% reported the use of prescription medications for their headaches. Combination analgesic agents with caffeine have been shown to be effective in clinical trials.^{72,73} Practice guidelines based on very limited published controlled data recommend NSAIDs and acetaminophen for acute care, while drugs of choice for the prevention of TTH are amitriptyline (first choice); mirtazapine or venlafaxine (second choice); and clomipramine, maprotiline, and mianserin (third choice).⁷⁴ For acute as well as preventive use, the potential side effects associated with these drugs may limit their tolerability. No drugs are FDA-approved for preventive TTH management. Management may also include behavioral methods such as relaxation training, biofeedback techniques, and physical therapy.⁷⁵ Of these nonpharmacologic therapies, the most evidenced-based approach is the combination of biofeedback with cognitive behavioral counseling.⁷⁶

Trigeminal Autonomic Cephalalgias

Cluster Headache (ICHD 3.1.x; ICD-10 G44.01x– G44.02x)

Clinical presentation and diagnosis

Cluster headache is a primary headache disorder that is classified along with similar painful conditions known as *TACs*.² According to the ICHD, “cluster headache is described as a severe, unilateral headache lasting 15 to 180 minutes.”² The headache is accompanied by

autonomic features, restlessness or agitation, or both. Autonomic features include ipsilateral conjunctival injection, lacrimation, nasal congestion, rhinorrhea, forehead and facial sweating, forehead and facial flushing, sensation of fullness in the ear, miosis, ptosis, and/or eyelid edema.² Cluster headache is considered to be one of the most severe pain conditions that humans can experience. The pain presentation is usually periorbital, supraorbital, temporal, or in any combination of these areas. The attacks may occur anywhere from once every other day up to eight times per day, often occurring during sleep. Bilateral pain presentation was found to occur in 3% of subjects. Side shifts occur in approximately 8% of subjects during an individual attack and in approximately 31% of patients between individual headaches or headache cycles.⁷⁷ The “cluster period,” in which the attacks occur daily or near daily, tends to last from 2 weeks to a few months. Cluster periods will often recur on an annual or biannual basis during the same seasons. Despite the unique features of cluster headache, only 21% of patients receive the correct diagnosis at the time of their initial consultation with a clinician.⁷⁷ The diagnostic delay for cluster headache has been found to average from 3 to 5 years.^{77,78} Factors responsible for the diagnostic delay may include reports of accompanying photophobia, nausea, vomiting, and alternating sides of the attack, all of which are also characteristic of migraine headache.⁷⁸ However, photophobia and phonophobia associated with cluster headache attacks tend to be unilateral, ipsilateral to the side of the headache as opposed to the bilateral presentation seen in migraine. Because of the location, severity, and abrupt onset of pain, cluster headache is often mistaken for trigeminal neuralgia, sinus disorders, or dental pain.⁷⁹ The latter is the reason why up to 45% of cluster headache patients are first evaluated for their condition by a dentist.⁸⁰ In one recent survey, 23% of cluster headache patients reported that they received an initial diagnosis of a tooth-

jaw-related issue.⁸¹ In a retrospective study of 14 patients presenting to a dentist with cluster headache symptoms, six patients were prescribed oral appliances, four had tooth extractions, three had occlusal equilibration, and two underwent endodontic procedures with unfavorable outcomes.⁸² Cluster headache may be *episodic* with more than 1 month of headache-free days per year (ICHD 3.1.1, *ICD-10* G44.01x) or *chronic* and occur for more than 1 year without remission or with remissions lasting less than 1 month (ICHD 3.1.2 *ICD-10* G44.02x). Between 80% and 90% of cluster headache patients have episodic cluster headaches, while 13% of them will progress to chronic.⁸³ Approximately one-third of chronic cluster headache patients will spontaneously remit to an episodic form.

Epidemiology

Cluster headache has traditionally been thought to primarily affect men; however, more recent studies have determined the sex ratio (male divided by female) to range from 1.3 to 14.0.⁸⁴ Fischera et al⁸⁴ found the prevalence of cluster headache in all adults, both men and women, to be 0.12%. A population-based, 1-year prevalence study in Germany found a similar prevalence.⁸⁵ The average age of onset of attacks is between 20 and 40 years old, but cluster headache has been reported in all age groups.⁸⁶ Approximately 73% of cluster headache patients are smokers or former smokers, and half of patients note that alcohol can trigger an attack during a cluster period. Over half of cluster headache patients have recurrent thoughts of suicide.⁷⁷

Pathogenesis

The obvious circadian and circannual periodicity of cluster headache presentation would suggest that the hypothalamus plays a significant role in the pathophysiology of this headache disorder.⁸⁷ In fact, functional MRI and

Box 5-3 Common medications used to treat cluster headache^{95,96}

Abortive

- 100% oxygen inhalation
- Selective serotonin receptor agonists (sumatriptan, zolmitriptan)
- Cocaine/lidocaine
- Octreotide

Prophylactic

- Suboccipital steroid injections
- Melatonin
- Verapamil
- Lithium

voxel-weighted morphometric MRI studies have identified a region of the posterior hypothalamus that is metabolically activated during attacks.^{88,89} This region is ipsilateral to the cluster attack pain presentation.^{88,89} Reports have described a close relationship between cluster headaches and sleep-disordered breathing.^{90,91} Kudrow⁹² postulated that altered hypothalamic influence on the brainstem centers controlling respiration and vasomotor function diminishes carotid chemoreceptor activity. This may explain the positive response of cluster headaches to oxygen as well as the relationship between cluster headaches and altitude and sleep-disordered breathing.⁹³

Management

The management of cluster headache is essentially pharmacologic, with the goal of shortening and alleviating the cluster headache attacks and shortening the cycle of attacks.⁹⁴ Similar to migraine therapy, management of cluster headache can be divided into symptomatic/abortive and prophylactic regimens (Box 5-3). Because of the short duration and severe pain experienced in cluster headaches, abortive agents must have a rapid onset to be useful. Recently, the Guidelines Committee

of the American Headache Society published evidence-based recommendations for the management of cluster headache.⁹⁵ The abortive agents demonstrating the best efficacy were found to be sumatriptan subcutaneous, zolmitriptan nasal spray, and high-flow oxygen. Sumatriptan and zolmitriptan are serotonin receptor agonists that are FDA-approved for the abortive management of migraine headache. Sumatriptan is FDA-approved in its subcutaneous injection formulation for the abortive management of cluster headache. High-flow oxygen is delivered via non-rebreathing mask at rates from 12 to 15 L per minute for approximately 15 to 20 minutes. Other agents considered “possibly effective” are sumatriptan nasal spray, oral zolmitriptan, cocaine/lidocaine nasal spray, and subcutaneous octreotide, a hormone-modulating agent.

Prophylactic therapies should ideally be initiated as soon as the cluster period begins. However, there are currently no agents cleared by the FDA for this indication. The only therapy to be considered as “effective” is suboccipital steroid injections. Civamide nasal spray, a synthetic capsaicin isomer that is supposedly less irritating and more effective than capsaicin but is not readily available in the United States, is considered as “probably effective.” All other agents are considered “possibly effective” or “ineffective,” or there is a lack of evidence to make any recommendations as to the efficacy of the agent.⁹⁵ Recent evidence seems to suggest that botulinum toxin may prove beneficial in some cases of cluster headache.⁹⁷ There are also limited data supporting the effectiveness of melatonin as a prophylactic agent.^{98,99} Typically, prophylactic therapy is continued for 1 month after the last cluster attack and then discontinued until the next cluster period begins.

Surgical interventions are considered for severe, intractable cases of cluster headache when pharmacologic therapy has failed to provide relief. Deep brain stimulation, occipital nerve stimulation, and γ knife radiation of the hypothalamus in patients with intractable

chronic cluster headaches have yielded promising results.^{100–105} External and implantable stimulators are currently being investigated for prophylactic and abortive therapy. In early trials, a novel handheld external vagus nerve stimulator showed promising results as a preventive and abortive therapy.¹⁰⁶ Likewise, early trials of an implantable sphenopalatine ganglion stimulator have been promising for abortive therapy.^{107,108}

Paroxysmal Hemicrania (ICHD 3.2.x; ICD-10 G44.03x–G44.04x)

Paroxysmal hemicrania is a headache with clinical characteristics similar to those of cluster headache, but the attacks are shorter in duration (2 to 30 minutes), more frequent, and equally prevalent in men and women.^{2,109} The attacks are likewise strictly unilateral, predominantly presenting in the periorbital region. Paroxysmal hemicrania is accompanied by one or more of the following unilateral signs or symptoms: lacrimation, conjunctival injection, rhinorrhea, nasal congestion, forehead and facial sweating and flushing, miosis, ptosis, and eyelid edema. Unlike cluster headache, restlessness and agitation are not part of the diagnostic criteria, and an additional diagnostic criterion is that the headache must be prevented “absolutely” by therapeutic dosages of indomethacin. Attacks occurring in periods lasting 7 days to 1 year separated by pain-free periods lasting 1 month or more are classified as *episodic* (ICHD 3.2.1, ICD-10 G44.03), and attacks occurring for more than 1 year without remission or with remissions lasting less than 1 month are classified as *chronic* (ICHD 3.2.2, ICD-10 G44.04).

Very little is known about the pathophysiologic mechanisms behind paroxysmal hemicranias. The similarity in clinical presentations and therapeutic outcomes has led to the suggestion that all TACs may share a common pathophysiology.¹¹⁰ However, that does not explain

why some TACs are absolutely responsive to indomethacin and others are not, nor why some TACs seem to be associated with circadian rhythms and others do not. A positron emission tomography (PET) imaging study in patients with paroxysmal hemicrania revealed activation of the contralateral posterior hypothalamus, ventral midbrain, red nucleus, and substantia nigra during the attack.¹¹¹ It is not yet known whether these structures are the actual generators of TACs or simply activate during an attack in response to an initiating factor located elsewhere in the brain. The ICHD diagnostic criteria require 100% responsiveness to a therapeutic dose of indomethacin, but a few cases of paroxysmal hemicrania have been reported as indomethacin-resistant.^{2,112,113} In a review of 74 paroxysmal hemicrania patients, Boes and Dodick¹¹⁴ found that as many as 25% did not respond to indomethacin. The response of paroxysmal hemicrania to sumatriptan has also been conflicting with some reports citing a good response while others found only a partial response or no response at all.^{115–118} Recent work by Prakash and Patell¹⁰⁷ found topiramate to be successful in some patients with paroxysmal hemicrania and other indomethacin-responsive headache disorders. A previous study by Cohen and Goadsby¹¹⁹ revealed similar outcomes.

SUNCT and SUNA (ICHD 3.3.x; ICD-10 G44.05x)

Short-lasting unilateral neuralgiform headache attacks with conjunctival injection and tearing (SUNCT) (ICHD 3.3.1, ICD-10 G44.05x) is a primary headache disorder first described by Sjaastad et al.^{120,121} This disorder has clinical diagnostic features that bear strong resemblances to those of cluster headache and paroxysmal hemicranias.¹²² SUNCT attacks are very brief (5 seconds to 4 minutes) and present with moderate to severe pain. The pain is unilateral and often orbital, supraorbital, or tempo-

ral, though it may be experienced anywhere in the head. The pain is commonly described as burning, stabbing, or electric in character with 3 to 200 attacks occurring per day. Ipsilateral conjunctival injection and lacrimation must accompany the pain. When conjunctival injection or tearing (but not both) is present, or when other autonomic symptoms such as those listed for paroxysmal hemicranias are present, the condition is known as *short-lasting unilateral neuralgiform headache attacks with cranial autonomic symptoms* (SUNA) (ICHD 3.3.2, ICD-10 G44.05x). SUNA is reported to occur approximately five times less frequently than SUNCT.¹²² The differential diagnosis for SUNCT/SUNA prominently includes trigeminal neuralgia. Compared with trigeminal neuralgia, SUNCT attacks are more likely to be located in the ophthalmic division of the trigeminal nerve (V1). While both trigeminal neuralgia and SUNCT/SUNA may be triggered by cutaneous stimuli, SUNCT/SUNA is less likely to do so and is also less likely to demonstrate a refractory period after attacks that may be so triggered.¹²³ Some reports based on open-label trials indicate that carbamazepine, lamotrigine, gabapentin, topiramate, and intravenous lidocaine may be effective in some patients with SUNCT/SUNA, but there are no available data from large-scale controlled trials.^{124–128} Unlike paroxysmal hemicrania and hemicrania continua, SUNCT/SUNA is not responsive to indomethacin.¹²³ It is also unresponsive to high-flow oxygen and subcutaneous sumatriptan, which are effective for cluster headaches.¹²³

Hemicrania Continua (ICHD 3.4; ICD-10 G44.51)

Hemicrania continua, first described by Medina and Diamond,¹²⁹ is a persistent one-sided head-

ache that fluctuates in intensity but never remits. Ipsilateral autonomic features and/or restlessness/agitation accompany this headache during periods of more intense pain, as they do in cluster headache. An absolute response to therapeutic dosages of indomethacin is necessary for a definitive diagnosis.² Hemicrania continua is considered a rare disorder but is most likely underdiagnosed.¹³⁰ Nausea, photophobia, and phonophobia may be present in approximately 50% of patients, similar to migraine.¹³¹ As with cluster headache, approximately two-thirds of patients with hemicrania continua will display restlessness or agitation during their attacks.¹³¹ Management typically consists of indomethacin, but gastrointestinal disturbances may make this agent unacceptable. Cardiovascular issues may also develop with long-term use of indomethacin.¹³² Alternative therapies may include the use of topiramate, greater occipital nerve blocks, and in select cases, greater occipital nerve stimulation.^{131,133,134}

Conclusion

Cluster headache, paroxysmal hemicranias, SUNCT/SUNA, and hemicrania continua are disorders considered to be TACs (Table 5-1). All of these disorders, except hemicrania continua, are characterized by relatively short-lasting, moderate to severe headaches with autonomic features, and all have also been associated with hypothalamic changes on imaging studies.^{123,124,135,136} Obtaining brain imaging with a focus on the pituitary region as well as laboratory pituitary function testing is recommended because pathologies in this area have occasionally been associated with TACs.¹³⁷

Table 5-1 Clinical features of TACs*

| Feature | Cluster headache | Paroxysmal hemicrania | SUNCT/SUNA |
|---|---|---|---|
| Sex (M:F) | 3:1 | 1:1 | 1.5:1 |
| Attacks <ul style="list-style-type: none"> • Frequency (no./day) • Length (minutes) | 1 to 8 30–80 | Mean of 11 2–30 | 3–200 0.1–4 |
| Pain <ul style="list-style-type: none"> • Quality • Severity • Distribution | Sharp/throb Very severe V1 > C2 > V2 > V3 | Sharp/throb Very severe V1 > C2 > V2 > V3 | Sharp/throb Very severe V1 > C2 > V2 > V3 |
| Triggers <ul style="list-style-type: none"> • Alcohol • Nitroglycerin • Cutaneous | +++ +++ – | + + – | – – +++ |
| Agitation/restlessness | 90% | 80% | 65% |
| Episodic vs chronic (%) | 90:10 | 35:65 | 10:90 |
| Circadian periodicity | Present | Absent | Absent |
| Management effects <ul style="list-style-type: none"> • Oxygen • Sumatriptan, 6 mg • SC indomethacin | 70% 90% No effect | No effect 20% 90% | No effect < 10% No effect |
| Migraine features with attacks <ul style="list-style-type: none"> • Nausea • Photo-/phonophobia | 50% 65% | 40% 65% | 25% 25% |

*Adapted from Goadsby et al¹²³ with permission.

V, trigeminal; C, cervical; SC, subcutaneous; +++, potent or definite trigger; +, sometimes a trigger; –, not a trigger.

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6

Neuropathic Pain

Key Points

- ◇ Clinicians need to recognize and understand that not all “toothaches” are of odontogenic origin.
- ◇ Episodic or continuous neuropathic pains may present with symptoms that mimic odontogenic pain, but these may require medical or surgical intervention instead of routine dental intervention. Repeated surgery and prescription of antibiotics are not indicated for neuropathic pain.
- ◇ Clinicians should have an understanding of neuropathic processes to avoid misdirected or incomplete treatment.
- ◇ Clinicians should have an understanding of the role of routine anesthetic and surgical techniques in the causation of neuropathic pain.
- ◇ Referral to other health care providers should be a consideration when patients present with complex and confusing symptoms.
- ◇ Management of neuropathic pain often requires a multidimensional and multidisciplinary approach, and early recognition and treatment of posttraumatic neuropathy may prevent chronic pain.

There are four types of pain: nociceptive pain, inflammatory pain, neuropathic pain, and dysfunctional pain¹ (Fig 6-1). These four types of pain can be divided into two broad groups: healthy protective pain and chronic dysfunctional pain. Protective pain includes both acute nociceptive pain and inflammatory pain. *Nociceptive pain* is a process of transduction and transmission to the sensory cortex whereby pain is registered in the region of tissue where the noxious stimulation has occurred, thereby warning the individual to limit the damage. *Inflammatory pain* is pain following tissue damage whereby peripheral and central mechanisms cause

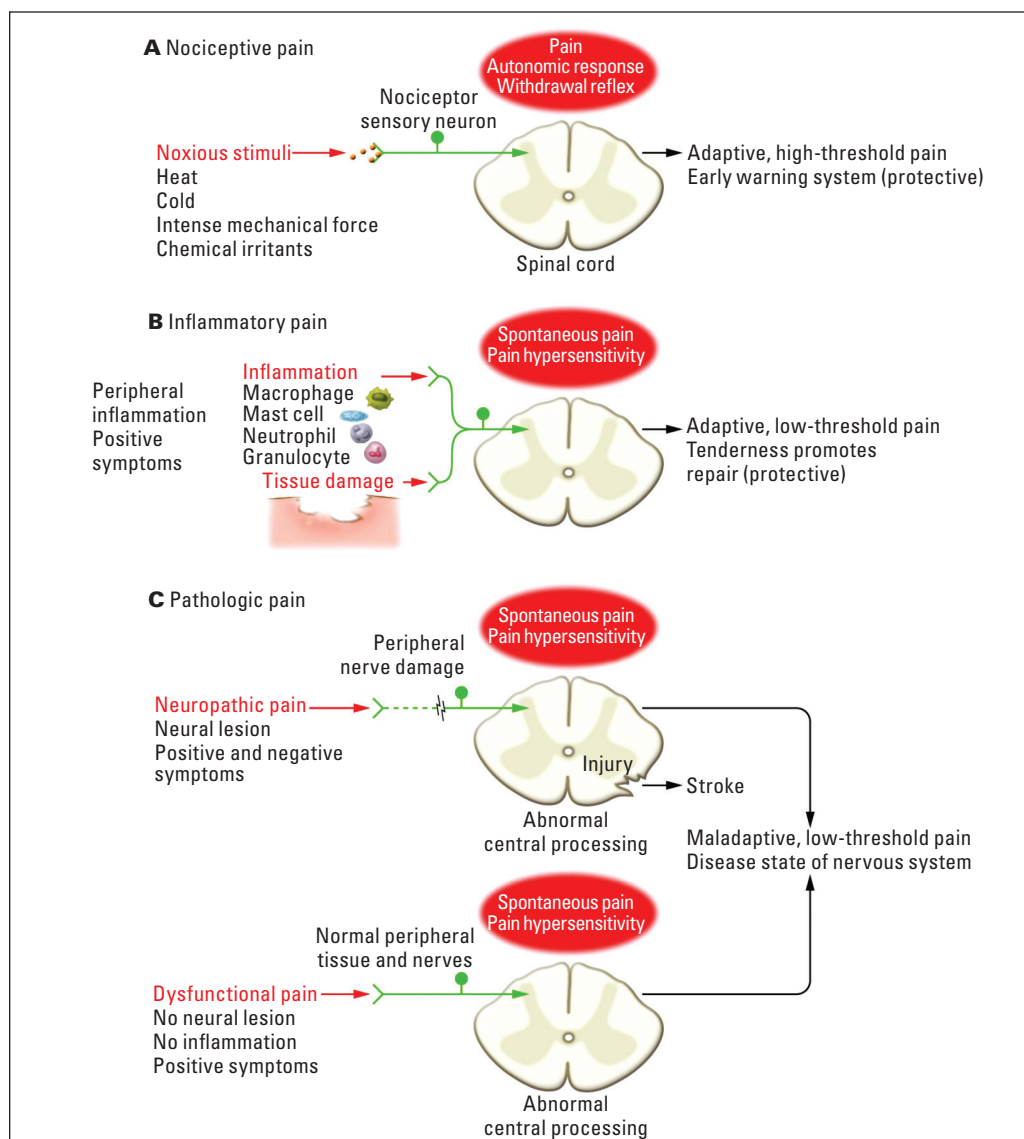


Fig 6-1 Differing types of pain. Reproduced with permission from Woolf.¹

sensitization of the damaged tissue and the nearby undamaged tissues. This pain thereby serves a protective purpose in helping facilitate tissue repair.

Chronic pain is a process where the brain continues to overlay pain in a body region when the tissues are healed. This type of pain

no longer serves a protective purpose as do the two healthy pain types. Chronic pain can either be due to nerve damage (neuropathic pain) or to pathology of the pain system (dysfunctional pain), which may be caused by amplification of pain signals in the central nervous system (CNS) and can share some of the signs

of neuropathic pain, including wind-up, hyperalgesia, and allodynia.²

Neuropathic pain is defined as pain that arises from injury, disease, or dysfunction of the peripheral or CNS, as compared with *somatic pain*, which occurs in response to noxious stimulation of normal neural receptors.³ Neuropathic pain is generally classified according to the agent of insult and anatomical distribution of the pain. Based on temporal features, neuropathic pain can be episodic or continuous and can be peripherally generated or centrally mediated. Often, both central and peripheral sensitization play a role in the continuation or persistence of the condition. Patients experiencing neuropathic pain may complain of a combination of spontaneous (stimulus-independent) or touch-evoked (stimulus-dependent) pain.⁴ Sensory signs and symptoms characteristically accompany neuropathic pain. These signs may be either *positive*, meaning gain in function (eg, hyperalgesia or allodynia to mechanical or thermal stimuli); *negative*, meaning loss of function (eg, numbness); or a combination of both, such as dysesthesia.⁵ The clinical presentation of neuropathic pain can be dependent on its origin and the initial insult that caused it.⁶

Throughout this chapter, the codes from the third edition of the International Headache Society's Classification of Headache disorders, third edition, beta version (ICHD)⁷ and *The International Classification of Diseases, Tenth Edition (ICD-10)* are presented for each disorder.

Neuralgia

Head and neck pains are mediated by afferent fibers in the trigeminal nerve, *nervus intermedius*, glossopharyngeal and vagus nerves, and upper cervical roots via the occipital nerves. Neuralgia can result when these nerves are stimulated by compression, distortion, other forms of irritation, or lesions in the peripheral

or central pathways. A common characteristic of this pain is a paroxysmal (very short-lasting), sharp, stabbing, or electric shock-like quality felt in the area innervated by the involved nerve and hence the so-called neuralgia. The pain is often triggered by mild and innocuous stimuli (allodynia). Neuralgia is named according to the nerve involved, with the most common type being trigeminal neuralgia (TN). Other neuralgias include glossopharyngeal and *nervus intermedius* (geniculate).

Trigeminal neuralgia (ICHD 13.1; ICD-10 G50.0)

TN, also known as *tic douloureux*, is a painful condition affecting the face in the distribution of one or more divisions of the trigeminal nerve unilaterally. The condition is characterized by brief (paroxysmal) electric shock-like or lancinating pains that are typically precipitated by nonpainful stimuli, such as washing or lightly touching the face, shaving, talking, or brushing the teeth. The pain may also be spontaneous in nature. The paroxysmal pains are usually severe, with a duration of seconds to a few minutes. Frequently, there is a refractory period following a paroxysm in which an outburst cannot be provoked. Sometimes, several paroxysms will occur in succession and fuse, with the patient describing a longer duration of pain. In addition, some patients who have frequent attacks of pain will describe a longer-lasting burning sensation in the same distribution.

The condition is marked by remission periods lasting days to years during which minimal or no pain is noted. The pain-free intervals usually become shorter and the exacerbations intensify as the neuralgia progresses.^{8–10} Attacks usually occur during waking hours but may also awaken the patient from sleep.^{11,12} Clinically, there do not appear to be any neurologic deficits.⁷ Very occasionally, attacks can be accompanied by autonomic features, but this is not typical.¹³ The second and third divisions of the

trigeminal nerve are most commonly affected; the first division is affected in only 1% to 2% of patients. The right side of the face is more often involved than the left; it was hypothesized that the nerve on the right side would be more often subject to entrapment because the right side foramen and ovale and foramen rotundum are smaller than the left.¹⁴ The pain does not cross the midline of the face, although the condition may affect the face bilaterally in as many as 3% to 5% of patients. The neurologic examination is normal.⁷ The average age of onset is approximately 50 years, and the prevalence has been estimated to be 107.5 men per million and 200.2 women per million.¹⁵

The term *trigeminal neuralgia* is a broad term that can be misinterpreted and unknowingly misused. The ICHD uses the overarching term *classical trigeminal neuralgia* (ICHD 13.1.1) to explain that this is TN with no cause identified other than neurovascular compression of the trigeminal nerve in the area of the dorsal root entry zone.⁷ The alternate diagnosis in the ICHD TN grouping (13.1) is *painful trigeminal neuropathy* (13.1.2), which accounts for some conditions that might mimic the signs and symptoms of classic TN and would have previously been known as *symptomatic* or *secondary TN* in the previous ICHD (second edition).¹⁶ However, it must be noted that many conditions in this group may produce continuous neuropathic pain as opposed to episodic neuropathic pain and therefore were probably not best grouped under the overarching category of TN in the current ICHD. Notwithstanding, continuous neuropathic pain conditions may occasionally produce some overlapping symptoms with TN. This may be clarified with further research and revised in the next edition of the ICHD. TN may also be more accurately considered a secondary neuropathy because it is diagnosed in relation to vascular compression of the trigeminal nerve's dorsal root entry zone.

The ICHD divides classic TN into two subtypes: paroxysmal classic TN (13.1.1.1) and classic TN with concomitant persistent facial

pain (13.1.1.2) (Box 6-1). This is because a significant proportion of classic TN patients describe brief paroxysmal attacks superimposed on a dull background pain. In a recent study, 30% of patients with typical short-duration attacks reported a persistent background pain in addition to the paroxysmal pain.¹⁷ The same study highlighted a subgroup of patients who report attacks lasting more than 2 minutes (according to ICHD criteria, classic TN has a cut-off at 2 minutes); the authors speculated that these patients may be reporting the paroxysm of neuralgic pain and the after pain as one. Previous studies have suggested a correlation between attack duration and disease duration.^{18,19}

In previous classifications of TN, there had been a defined entity of pretrigeminal neuralgia, but this is now subsumed into the two categories of classic TN in the ICHD. However, practitioners should still be aware that it may be possible for patients to present for several months in an almost "prodromal" phase of dull continuous toothache before developing symptoms consistent with classic TN or classic TN with concomitant persistent facial pain.²⁰⁻²² Successful management of pretrigeminal neuralgia is possible with similar medications as used for classic TN.²¹

Any of the presentations of TN discussed here can present a challenge to the clinician's diagnostic process because they may mimic odontogenic pain, depending on the state of the dentition and the clarity of the patient's history. This might cause clinicians to be led away from a diagnosis of TN. The opposite is also true in that many other conditions can also mimic TN, including painful trigeminal neuropathies arising from demyelination (eg, multiple sclerosis [MS]), space-occupying lesions (centrally or peripherally) or trauma, dental pain, and trigeminal autonomic cephalalgias. According to the ICHD, pathology producing painful neuropathic symptoms that mimic TN are now classified in a group listed as *painful TN* (ICHD 13.1.2) as opposed to their previous classification as *symptomatic* or *secondary TN*.

Box 6-1 Summary of presenting features of classic TN purely paroxysmal and classic TN with concomitant facial pain as defined by the ICHD⁷

Classic TN purely paroxysmal

- At least three attacks of unilateral facial pain occurring in one or more of the trigeminal nerve dermatomes.
- Pain must have at least three of the following characteristics:
 - Recurring attacks of a paroxysmal nature (duration of attack: from less than 1 second to up to 2 minutes)
 - Severe intensity
 - Character/quality: electric shock, shooting, stabbing, or sharp
 - Triggered by innocuous stimuli to face (some can be spontaneous, but there must be at least three triggered by innocuous stimuli)
- No clinically evident neurologic deficit.
- No persistent pain between attacks.
- Not better accounted for by another ICHD diagnosis.

Classic TN with concomitant facial pain

- Recurrent attacks fulfilling criteria for classic TN purely paroxysmal.
- Between paroxysms of pain, there is a persistent pain of moderate intensity in the affected dermatome.
- This group of conditions was previously known as *atypical TN* or *TN type 2*.

Pathogenesis

The pathogenesis of classic TN is not completely understood, but there are many hypotheses. Classic TN has been investigated as a result of *demyelination*, the loss of the insulating myelin sheath that separates individual nerve fibers. The cause of the demyelination is most frequently compression of the trigeminal nerve root close to its entry into the pons by overlying blood vessels.²³ This compression and resultant deformation of the trigeminal nerve root and some of its insulating myelin are thought to allow for spontaneous and ectopic nerve firing with ephaptic cross-talk among adjacent fibers (cross-stimulation of C-fibers).²⁴ This hypothesis may account for the presentation of innocuous stimuli, resulting in spontaneous perception of pain. Some researchers have reported familial TN, suggesting that

there are genetic traits that are autosomal dominant. For instance, Charcot-Marie-Tooth disease is an autosomal-dominant sensory motor type I neuropathy that is associated with peripheral demyelination and can therefore produce TN-like symptoms.²⁵

Although there appears to be a strong association between demyelination and TN, demyelination theories alone do not account for many of the characteristics of this particular neuropathy. Devor et al²⁶ proposed the ignition hypothesis, which takes the demyelination theories one or more steps further. The ignition hypothesis attempts to explain the following phenomena:

- **Triggering:** How a trigger stimulus such as light touch can cause severe pain that long outlasts the stimulus.

- **Amplification:** How the innocuous stimulus results in a spreading response far beyond the area innervated by the originally stimulated nerve fibers.
- **Stop mechanism:** How the pain response is sustained for a period of time and then actually stops itself.

Rappaport and Devor²⁷ explained 13 out of 14 key features of TN based on neuronal abnormalities related to nerve injury. In most cases, this injury is related to nerve root compression, but other forms of injury may apply. Nerves that are injured become hyperexcitable and therefore may fire with little or no stimulus. These so-called ectopic pacemaker sites may actually be at points of demyelination or at the ends of severed nerves.²⁶ Some sites may fire continuously at a low level and produce a dull, background, burning pain, and others may require only the slightest stimulation to produce a long-lasting burst of impulses that result in severe pain lasting long beyond the initial stimulus.²⁸ Nerve fibers may recruit other adjacent fibers and so on, causing short-lasting shooting pain from one point to another.²⁷ Once ignited, there can be further amplification of the pain by ephaptic transmission or electrical cross-talk between nerve fibers at a site of injury or compression, whereby the adjacent nerve fibers have lost their insulating neural sheaths, allowing direct “short circuit” stimulation.²⁹ The stop mechanism can be explained by hyperpolarization of the neuron. This stops the burst, and until the ionic imbalance returns to its prestimulation levels, the nerve fiber can no longer be stimulated.²⁶ Not only is the burst of pain stopped, but it also cannot be triggered again for a period of time. This period is called the *refractory period*.

In the majority of patients who have undergone surgical treatment for TN, microvascular compression of the trigeminal nerve root was identified. These patients mostly responded well to microvascular decompression (MVD) surgery. Compressive damage of trigeminal ganglion

has been found in patients as well.³⁰ If no pathologic factor other than vascular compression is identifiable, the neuralgia is classified as classic TN, previously known as *primary* or *idiopathic TN*. The vast majority (> 85%) of TN patients are diagnosed with classic TN. If the neuralgia is caused by a verifiable lesion such as a tumor, epidermoid cyst (eg, acoustic neuroma or meningioma), cholesteatoma, osteoma, aneurysms, or vascular malformations, it is not classified as TN, but as either painful trigeminal neuropathy attributed to space-occupying lesion (ICHD 13.1.2.5) or painful trigeminal neuropathy attributed to other disorder (ICHD 13.1.2.6).³¹ Classic TN must therefore also be differentiated from other extracranial causes of facial pain, including local dental disorders, sinus disease, head and neck neoplasms, and infections and headache (or facial pain) associated with a temporomandibular disorder (TMD) (ICHD 11.7). Additionally, three other pain conditions that have to be considered in the differential diagnosis are short-lasting unilateral neuralgiform headache attacks with conjunctival injection and tearing (SUNCT; ICHD 3.3), short-lasting unilateral neuralgiform headache attacks with cranial autonomic features (SUNA; ICHD 3.3) and primary stabbing headache (ICHD 4.7). These three conditions predominantly affect the first division of the trigeminal nerve in contrast to classic TN, which mostly involves the second and third divisions. Imaging studies of the head and brain may be indicated as part of identifying other causes of the pain.

Treatment

The treatment for classic TN can be divided into two modalities: medical and surgical.

Medical management

Carbamazepine is the most effective medication for classic TN with a number to treat of 1.9 (95% confidence interval: 1.6 to 2.5) for > 50% pain relief.³² The initial response to carbamazepine is good (70%) but drops dramatically (20%) after 5 to 16 years of use.³³ The start-

ing dosage is 100 mg/day, and then the dosage is increased by 100 mg every 2 weeks to a maximum of 1,200 mg/day in a divided-dose regimen. A beneficial effect is often apparent within hours to a couple of days after starting this medication. The most common side effects include drowsiness, dizziness, unsteadiness, nausea, and anorexia. These are often transient and can be reduced by starting with a low dose and increasing the dose slowly. Aplastic anemia is a rare side effect, while a transient elevation in liver enzymes may occur in 5% to 10% of patients, and transient leukopenia may manifest in 5% of patients (persistent in 2%). Therefore, patients taking this drug need to have their blood levels carefully monitored for these potential complications. One suggested protocol for monitoring for the side effects of carbamazepine is given by Reisner and Pettengill³⁴:

- Perform a complete (full) blood count (CBC) and urea and electrolytes (U&E) preadministration and every 2 to 4 weeks for the first 3 months. If the total white cell count decreases, then stop usage (this is most likely in the first 3 months).
- Perform liver function tests at baseline and then every 6 weeks. If they are normal for two intervals, then discontinue the tests.
- After close monitoring over the first 3 months, consider checking CBC and U&E every 3 months or twice per year.

The other rare complication of carbamazepine use in a Caucasian population is Stevens-Johnson syndrome (SJS) or toxic epidermal necrosis (TEN) (0.01% to 0.06% incidence). SJS and TEN are differentiated by the extent of skin detachment, with < 10% body surface involvement for SJS and > 30% for TEN. There is a strong association between a human leucocyte antigen (HLA) allele HLA-B*15:02 and carbamazepine-induced SJS. Only 1% to 2% of Caucasians are genetic carriers of this allele as opposed to Han Chi-

nese or Thai (Southeast Asian) populations, where 15% of the population are carriers. This results in a much greater risk of SJS in this population, and HLA screening has shown to be cost-effective and is recommended for these populations prior to prescription of carbamazepine by both the US Food and Drug Administration in the United States and the Medicines Healthcare Regulatory Authority in the United Kingdom.³⁵⁻³⁷

Sustained or slow-release preparations of carbamazepine have improved compliance and reduce the sedating side effects of the drug. A recent Cochrane Database systematic review of the efficacy of carbamazepine for the treatment of classic TN revealed only five placebo and three active randomized controlled trials (RCTs). The numbers in the studies that could be evaluated were small but showed that there is evidence that carbamazepine is effective in the treatment of TN.³²

Oxcarbazepine, a keto-analog of carbamazepine, may be equally effective in the treatment of TN.^{38,39} Oxcarbazepine can be begun at 150 mg twice daily, increasing the daily dose as tolerated up to 300 to 600 mg twice daily with a maximum dose of 2,400 mg/day. The side effect profile of oxcarbazepine is less severe than that of carbamazepine; however, hyponatremia occurs more frequently when using oxcarbazepine.⁴⁰ Oxcarbazepine is now becoming the most likely second drug of choice after carbamazepine and may replace it as the first-choice drug as new evidence emerges.⁴¹

Alternatives to oxcarbazepine include augmenting carbamazepine through the use of baclofen, which has a synergistic effect when coprescribed with carbamazepine.⁴² Following this, the next best alternative is lamotrigine, which has been validated for refractory cases, especially in TN due to MS, with doses between 100 and 400 mg daily.⁴²⁻⁴⁴ Side effects may include diplopia, dizziness, headache, and gastrointestinal symptoms. Dermatologic reactions, including SJS, occur in around 0.1% of patients and often present within 2 to 9

weeks of beginning treatment, so lamotrigine should be discontinued as soon as possible at the first sign of any form of rash.⁴³

Other anticonvulsants lack sufficient evidence to trial them as first- or second-line medications in the absence of specific indications:

- Phenytoin has been prescribed for the treatment of TN. However, long-term success was achieved in only 25% of cases when used alone. The combination of phenytoin and baclofen appears to be more effective.^{45,46} Common side effects are drowsiness, dizziness, and gastrointestinal symptoms.
- Gabapentin may be an alternative treatment. Compared with carbamazepine and phenytoin, gabapentin has minimal side effects and is better tolerated by older patients.^{47,48} However, there are no RCTs specifically investigating the efficacy of phenytoin or gabapentin for TN.^{49,50}
- Pregabalin, an antiepileptic drug structurally related to gabapentin, has shown to be efficacious in the treatment of TN in an open-label study and according to patient-reported outcomes.^{51,52}
- Topiramate has shown initial promise, and in a meta-analysis comparing topiramate with carbamazepine, it was reported that there seemed to be no differences in the overall effectiveness and tolerability between these two medications in the treatment of classic TN; however, a favorable effect of topiramate was present after a 2-month duration.^{53–55} Topiramate can be begun at 25 mg once daily, increasing it slowly by 25 mg every 2 weeks, towards a daily dosage of 100 to 400 mg divided twice daily. Side effects include weight loss, somnolence, anxiety, psychomotor disturbance, urinary/renal calculi, and glaucoma.

Cochrane database systematic reviews concluded that there is insufficient evidence

from RCTs to advocate the use of nonseizure medications, including tizanidine, tocainide, proparacaine hydrochloride, pimozide, clomipramine, and amitriptyline, for the treatment of TN. Overall, the methodologic quality of the studies was considered poor, and side effects associated with the medications were common.⁵⁶

Surgical management

A number of peripheral and central surgical procedures have been suggested as management techniques for TN.⁴¹ Peripheral surgical techniques include neurectomy, cryotherapy, and alcohol injection. Surgical techniques aimed at the trigeminal (gasserian) ganglion often aim to disrupt or destroy nervous tissue and include radiofrequency thermocoagulation, percutaneous glycerol rhizotomy, and percutaneous balloon microcompression. The central surgical techniques include MVD and stereotactic radiosurgery (gamma knife) surgery.

Neurectomy is a peripheral ablative procedure in which the offending trigeminal nerve branch is avulsed under local or general anesthesia. Success rates for neurectomy are conflicting (50% to 64%) and involve relatively small series with short-term follow-up.⁵⁷ Common side effects are hypoesthesias and paresthesias, and pain recurrence is frequent.^{58,59}

Cryotherapy is a peripheral ablative procedure in which the offending trigeminal branch is frozen under general or local anesthesia. A specially designed probe allows the procedure to be performed without surgical exposure of the nerve.⁶⁰ Generally, the effects of cryotherapy are short lasting (6 to 12 months), although longer pain relief has been reported.^{60–62} Side effects may include dysesthesia and/or sensory deficits.

Alcohol injections are performed under local anesthesia. After the affected branch of the trigeminal nerve is anesthetized, a small amount of absolute alcohol is deposited. Compared with neurectomy and radiofrequency

thermocoagulation, alcohol blocks result in a higher percentage of recurrence but fewer side effects.⁵⁸ Side effects typically include hypoesthesia, paresthesia, and dysesthesia as well as the potential for tissue fibrosis, reactivation of herpes zoster, and bony necrosis.⁵⁷ Duration of pain relief is generally less than 1 year.⁶³ However, the procedure can be repeated without impact on the extent or duration of pain relief.⁶³ Because of the risk of developing neuropathic pain, peripheral procedures should really only be used for patients with significant medical comorbidities that would make other surgical treatments or management techniques unsafe.⁵⁷

Three types of trigeminal ganglion procedures are available for treatment of TN. Percutaneous radiofrequency thermocoagulation and percutaneous glycerol rhizotomy are neurosurgical procedures in which a fluoroscopically guided needle is inserted through the foramen ovale of the patient under sedation. After careful manipulation of the needle and feedback from the patient, the selected nerve fibers are destroyed by thermal lesioning or by injection of anhydrous glycerol.^{64–66} Corneal numbness and masseter weakness are the most common complications of radiofrequency thermocoagulation (10% to 12%).⁶⁷ Corneal numbness and dysesthesia are the most common complications of percutaneous glycerol rhizotomy (8% each).⁶⁷

Percutaneous balloon microcompression is a neurosurgical procedure in which the trigeminal nerve is compressed by inflating a tiny balloon in the area of the involved nerve fibers.^{68,69} The needle placement is similar to that of the other two procedures. Reports show high rates of immediate pain relief with balloon compression (91% to 100%), and the recurrence rates at 12 to 18 months were low (2.5% to 5%).^{70–72} A retrospective study with an average follow-up time of almost 11 years reported 19% recurrence within a 5-year period and 32% recurrence over a 20-year period.⁷³ Side effects of this procedure include numb-

ness and dysesthesia, the severity of which may be related to the amount of compression applied.⁷⁰ Transient masseter weakness is reported with high frequency.⁷⁴ Other complications include arterial and cranial nerve injuries.

An alternative to rhizotomy is MVD of the trigeminal ganglion and dorsal root, first described in 1952 by Taarnhøj⁷⁵ in Denmark and by Love⁷⁶ in the United States. Jannetta⁷⁷ refined and popularized this procedure, which involves a postauricular craniotomy into the posterior fossa, allowing its exploration. The cortex is carefully lifted, exposing the root entry zone of the trigeminal nerve while the offending vessel or lesion responsible for compressing the nerve root is located. The superior cerebellar artery is the most common offending vessel. The vessel is carefully dissected from the trigeminal nerve, and a separator (often some form of sponge) is placed between the structures, often resulting in immediate success. Although MVD appears to have great long-term success in terms of duration of effect and decreased neuropathic adverse effects, a major surgical procedure is required, along with its accompanying morbidity (0.3% to 3%) and mortality.⁷⁸ Patient selection is therefore extremely important. Relatively young, healthy patients are the best candidates.

The identification and then selection of patients with sufficiently significant vascular contact for MVD procedures is also problematic. In a recent prospective study from the Danish Headache Centre, 135 patients with classic TN were assessed by high-quality blinded magnetic resonance imaging (MRI).⁷⁹ These investigators found that on both the symptomatic and asymptomatic sides (89% and 78%, respectively), some form of contact between the adjacent vasculature and trigeminal dorsal root entry zone was common. However, severe displacement or atrophy of the trigeminal nerve occurred more often on the symptomatic side.

A minimally invasive method to treat TN is stereotactic neurosurgery (gamma knife surgery). Precisely focused radiation of 40 to 90

Gy emitted from 201 photo beams is applied to the trigeminal root entry zone in the posterior fossa. Compared with other procedures, onset of pain relief is delayed.⁸⁰ Reports of pain relief vary from 61% to 92%, while recurrence rates vary from 10% to 27%.^{80–83} Dysesthesia is the most prominent side effect related to stereotactic radiosurgery (9%), and this appears inversely related with pain control.^{67,84–86} Repeat surgeries seem to be as efficacious as initial surgeries.^{84–87} Safety and efficacy of the procedure after more than one repeat surgery have not yet been definitively established, and repeat surgery should be used selectively because limited data are available on the effects of cumulative radiation dose.^{88,89} Furthermore, data are also lacking on which patients to treat with a repeat surgery and, when treated with a repeat surgery, which target to aim for and with which dose.⁹⁰ From the limited data available, results may suggest that those who developed facial numbness following the first surgery along with a good pain response are more likely to benefit from a second surgery, if required.^{87,91}

There are no RCTs comparing different types of surgeries or comparing surgeries with medications for TN. A thorough systematic review including only high-quality studies with actuarial data evaluated the treatment efficacy of radiofrequency thermocoagulation, percutaneous glycerol rhizotomy, percutaneous balloon compression, and stereotactic radiosurgery.⁶⁷ This review revealed that, whereas radiofrequency thermocoagulation showed the longest pain relief, the complications, though transient, were also the most frequent. Radiofrequency thermocoagulation and percutaneous glycerol rhizotomy yielded higher percentages of complete pain relief at 6, 12, and 24 months than stereotactic radiosurgery. However, the pain-relieving effects of glycerol rhizotomy rapidly declined after 2 years. It has been reported that MVD and balloon compression have the best prospects to improve the quality of the patient's life. Percutaneous

glycerol rhizotomy and radiofrequency thermocoagulation also yielded favorable results, whereas medications were the least likely to improve the patient's quality of life.⁹² A systematic review concluded that there is a paucity of high-quality evidence for the efficacy of most neurosurgical procedures (no studies of MVD met inclusion criteria). All the surgical techniques examined in the review produced variable pain relief, but several also resulted in sensory side effects.⁹³

The American Academy of Neurology and the European Federation of Neurological Societies have all published guidelines regarding TN management (medical and surgical), and the International Association for the Study of Pain (IASP) neuropathic pain special interest group has also published a review of interventional management in neuropathic pain.^{94,95} The IASP review concluded that, on the basis of the current evidence, either peripheral procedures are ineffective or there is a lack of evidence of their effectiveness. On the basis of the current literature, there is inconclusive, low-quality evidence for recommending MVD, radiofrequency or glycerol rhizotomy, balloon compression, or stereotactic radiosurgery; however, consideration should be given to using these in the face of classic TN refractory to medical management because patients would seem to benefit from them. The choice between these surgical strategies is based on a level of certainty of diagnosis of TN, socio-demographics, patient preference, patient's general health, local expertise, and the presence or absence of vascular compression on MRI.

Glossopharyngeal neuralgia (ICHD 13.2; ICD-10 G52.1)

Glossopharyngeal neuralgia (ICHD 13.2) is similar in character to TN but is present in the distribution of the glossopharyngeal nerve and may be present in the distribution of the auricular and pharyngeal branches of the vagus nerve. The pain is typically severe; transient; stabbing

or burning; and located in the ear, base of the tongue, tonsillar fossa, or beneath the angle of the jaw. Estimates of its incidence are fraught with methodologic difficulty but are thought to be about 0.7/100,000 per annum with little sex differentiation.⁹⁶ The pain is unilateral, although 1% to 2% of patients may experience asynchronous bilateral pain. The paroxysms of pain usually last seconds to 2 minutes and are provoked by swallowing, chewing, talking, or yawning. There may also be concomitant vagal symptoms given the neuroanatomy of the glossopharyngeal and vagus nerves. Glossopharyngeal neuralgia may relapse and remit like TN.⁹⁷ The co-occurrence of TN and glossopharyngeal neuralgia is common and expected to occur in 10% to 12% of glossopharyngeal neuralgia patients.⁹⁷ The neurologic examination is normal. The pathophysiology is thought to be similar to that of idiopathic TN.

The evaluation of a patient with glossopharyngeal neuralgia should include an MRI scan with contrast to exclude a glossopharyngeal neuralgia secondary to other pathology either centrally or peripherally arising from such pathology as posterior fossa tumors, fusiform (dolichoectatic) vertebral or basilar arterial pathology, vascular anomalies, infection affecting the course of the glossopharyngeal nerve peripherally, and nasopharyngeal tumors. Effective treatment can often be accomplished with the same anticonvulsant medications used for the treatment of TN, such as carbamazepine, oxcarbazepine, baclofen, phenytoin, and lamotrigine either alone or in combination.^{38,98} Surgical procedures include intracranial sectioning of the glossopharyngeal nerve and the upper rootlets of the vagus nerve and MVD of the glossopharyngeal nerve or gamma knife surgery.^{99,100}

Nervus intermedius neuralgia (ICHD 13.3; ICD-10 G51.9)

Nervus intermedius neuralgia is a rare condition that is characterized by unilateral paroxysms of pain felt in the depth of the ear and

lasting seconds or minutes. An alternative term used for this condition is *geniculate neuralgia* because the cell bodies of the sensory afferents are located in the geniculate ganglion. There is often a trigger zone in the posterior wall of the auditory canal. Disorders of lacrimation, salivation, and taste are sometimes present. Nervus intermedius neuralgia is now subclassified in the ICHD into classic (13.3.1) and secondary nervus intermedius neuropathy (13.3.2, previously known as *Ramsay Hunt Syndrome*) attributed to acute herpes zoster with the former having no apparent cause and the latter requiring evidence of causation by herpes zoster and facial paresis. The evidence for causation by herpes zoster includes a vesicular eruption in the ear and/or oral mucosa that was preceded by pain less than a week before the eruption.^{6,16,101,102} Medications used for TN may be trialed. Surgical section of the nervus intermedius or chorda tympani may relieve the pain. Local ear disorders must be ruled out.

Painful Trigeminal Neuropathies (ICHD 13.1.2)

A large amount of work has occurred to try and develop a more accurate diagnostic classification of trigeminal neuropathies. Some of the work in painful posttraumatic trigeminal neuropathies (PPTNs) has been at slight cross purposes with other research in the area, and efforts are underway to clarify the situation through organizations such as InFORM (previously known as the International Research Diagnostic Criteria for TMDs [RDC/TMD Consortium Network]), the American Academy of Orofacial Pain (AAOP), and the IASP's special interest group in orofacial pain. Readers should keep abreast of changes in the next few years as the field is currently in a state of flux due to the confusing nomenclature in the literature, which presents difficulties from taxonomic and ontologic perspectives.

Numb chin syndrome

Prior to discussing the various subtypes of painful trigeminal neuropathies, it is pertinent to mention and clarify a predominantly non-painful condition whose definition and use seems to have gained favor in recent years. This increase in use is presumably, and understandably, because of its desirable facilitatory function in teaching as a simple heuristic, but its use has no real taxonomic or ontologic basis. The condition is *numb chin syndrome*, which is essentially a mental or inferior alveolar nerve sensory neuropathy. Features of this syndrome are anesthesia, paresthesia, and—very occasionally—dysesthesia in the mental dermatome.¹⁰³ Mental neuropathy can be caused by a variety of events, disorders, or diseases, including dental procedures (eg, local anesthesia, implants, surgical endodontics) and pathologies (eg, odontogenic infection or neoplasia in close proximity to the nerve).^{104–111}

The presence of signs and symptoms of numb chin syndrome should not be considered lighthearted in the absence of odontogenic causes because they can be related to local or systemic malignant neoplastic conditions.^{112–114} In recent years, numerous case reports have been published indicating a wide variety of underlying causes, including but not limited to MS, use of antiresorptive medications (bisphosphonates), vagal and hypoglossal paralysis, leukemic vasculitis, non-Hodgkin lymphoma, B-cell lymphoma, and other metastatic cancers. Under these circumstances, immediate referral to the relevant medical practitioner is paramount. Signs and symptoms of numbness should not be dismissed because they play an important part in ensuring health professionals are aware of its potential red flag status. It does not however constitute a diagnosis, and because it is rarely painful, it does not really fit into the current ICHD unless it is painful and/or is due to either a systemic cause or a traumatic cause.

Painful peripheral sensory neuropathies

Expanding the discussion regarding numb chin syndrome, if a wider perspective of painful peripheral sensory neuropathies (PPSNs) affecting the whole body is taken, it is possible to consider PPSNs to be either primary or secondary (as has been seen in the preceding discussion of numb chin syndrome).¹¹⁵ If PPSNs are primary, they are neuropathic pain prior to any active intervention; in the trigeminal system, this would include conditions previously known as *pretrigeminal neuralgia* and *phantom tooth pain*, which are now hypothetically and conceptually considered (in part) as *persistent dentoalveolar pain disorder* (PDAP) and/or *PPTTN* (see later section). This type of primary PPSN can be difficult to diagnose because it is poorly understood, but it must be excluded prior to dental treatment because it may represent half of all cases of persistent tooth pain.^{116,117}

Secondary PPSNs may be due to a variety of disorders including hereditary sensory neuropathies (eg, Fabry disease), multifocal lesions of the peripheral nervous system (eg, polyarteritis nodosa causing mononeuritis multiplex), and generalized lesions of the peripheral nervous system (eg, polyneuropathies such as diabetes mellitus). Lesions of the CNS (eg, spinal cord injury) and complex neuropathic disorders (eg, complex regional pain syndrome [CRPS] types 1 and 2) may also give rise to neuropathic pain. The most common conditions causing secondary painful trigeminal neuropathies include the following:

- PPTTN
- Painful trigeminal neuropathy attributed to acute herpes zoster
- Postherpetic trigeminal neuropathy
- Painful trigeminal neuropathy attributed to MS plaque

PPTN (ICHD 13.1.2.3)

PPTN was previously classified as *anesthesia dolorosa* in the second edition of the ICHD (13.18.1) as a painful area of anesthesia or dysesthesia in the trigeminal nerve distribution. It can arise following peripheral or central (neurosurgical) damage to the trigeminal nerve, ganglion, or nuclear complex, such as that occurring in some neurosurgical management strategies for TN. As a type of deafferentation pain, PPTN is feared most with rhizotomies, but a review revealed a low incidence rate of PPTN (less than 2%) after radiofrequency thermocoagulation and glycerol injections.⁶⁷ Balloon microcompression, MVD, and gamma knife surgery have not typically been associated with the development of PPTN.^{71,81,118–120} In addition to the characteristic pain, a feature of this condition is decreased sensitivity to pain and temperature in one or more divisions of the trigeminal nerve. Accordingly, central pain results from lesions that affect the trigeminothalamic pathways. Very few studies are available with regard to the treatment of *anesthesia dolorosa*. Therefore, treatment remains anecdotal and usually consists of tricyclic antidepressants and anticonvulsants. Microsurgical repair has shown to be effective in only one out of seven patients.¹²¹ Dorsal root entry zone lesioning has shown some promise in the treatment of *anesthesia dolorosa*, as has sensory thalamic neurostimulation.^{122,123}

What was previously known as *atypical odontalgia* has been subsumed into PPTN or PDAP because of the emerging opinion that atypical odontalgia is likely, at least in part, to be neuropathic in origin.¹²⁴ The use of PPTN or PDAP to label cases previously known as atypical odontalgia is dependent on which classification system one feels is more robust. In essence, the disorders previously grouped under atypical odontalgia are likely to be characterized by^{124–127}:

- Persistent pain in a defined area of the dentoalveolus for more than 4 months, which can oscillate in intensity
- Pain characteristics that may include dull aching or burning, worsening pain with changes in barometric pressure, pain or pressure feeling deep within the bone, prickly or itching feelings, difficulty in communicating nature or character of pain
- Potentially presenting more frequently in females than in males (proposed 3:1)
- Usually following a deafferentation injury (eg, extraction or extirpation)
- Equivocal response to local anesthesia
- More frequent presentations in anterior teeth and in the maxilla

This group of conditions produces a colloquial phantom tooth pain. This pain may occur in situations of extirpation and root canal treatment of the tooth that is still in situ despite no demonstrable failure of the root canal treatment or through extraction of the tooth and ongoing pain despite demonstrable clinical and radiographic healing. Given the likely neuropathic nature of PPTN and PDAP, management of a diagnosed deafferentation phantom tooth pain (ie, PPTN or PDAP) follows the same principles of either topical or systemic neuromodulation covered later in this section.

Recent advances in this group's diagnosis include the use of quantitative sensory testing (QST) and/or qualitative sensory testing (QualST) and the development of a self-report screening instrument.^{128–130} QST has shown to be reliable intraorally and highlighted objective somatosensory differences between patients suffering from atypical odontalgia and control groups.^{131,132} QST is, however, a time-consuming and equipment-dependent process, given its uses. There are 13 tests to examine A δ , A β , and C-fiber function and temporal summation (wind-up), and therefore it is not suited for routine everyday clinical practice. QualST is an abbreviated form of QST that achieves results comparable with QST

using simpler equipment available in all clinical facilities: cotton wool, ice-cold spatula, and dental probe or explorer.^{128,129} The ipsilateral affected side is tested for sensory loss or gain compared with the contralateral side. Sensory loss or gain on the ipsilateral side is one indication that PPTN or PDAP may be present. It is also possible to examine wind-up using QualST, and a good description of both QST and QualST has been previously reported.¹³³ A self-report screening instrument consisting of 13 questions has also demonstrated preliminary promise during pilot testing.¹³⁰ This screening instrument concentrates on the key features of PPTN and PDAP within the patient's complaint as described earlier. It is currently under review and will be published in open access shortly.

Risk factors for any postsurgical neuropathy

Prevention of chronic postsurgical pain with or without neuropathy may be possible. Risk factors evident in diseases and disorders affecting other areas of the body may translate to the orofacial region. Considerations for identification of risk factors may include some of the following^{134,135}:

Perform preoperative screening for unusual presentations of pain before and after surgery. Neuropathic pain can develop slowly over time, so clinicians should always be cognizant of its putative diagnosis. There are validated diagnostic screening tools available to help with neuropathic pain, although to date the sensitivity and specificity of these instruments are deemed low when used with orofacial neuropathies.^{136,137} The screening tools include the following:

- Leeds Assessment of Neuropathic Symptoms and Signs (LANSS) or its self-reported version (S-LANSS)
- Neuropathic Pain Questionnaire (NPQ)
- Douleur Neuropathique en 4 (DN4)
- painDETECT
- ID-Pain

Perform preoperative screening for patient-specific factors such as the following:

- **Genetics:** Haplotype for catecholamine-O-methyltransferase
- **Preceding pain:** Intensity and chronicity
- **Psychosocial factors:** Anxiety, depression, fear avoidance, self-efficacy, work, physical levels of activity, somatization, anxiety, catastrophizing
- **Younger age:** Increased risk of neuropathic pain following breast surgery and herniorrhaphy
- **Older age:** Increased risk of neuropathic pain following other surgery
- **Female sex:** Increased risk of neuropathic pain¹³⁴

Surgical risk factors may be potentially modifiable. They include the duration and extent of surgical procedure and technique (eg, tension due to retraction of tissues) and level of reported perioperative pain intensity. Modifications to account for these risk factors may include:

- Multimodal management of severe acute postsurgical pain
- Minimal access surgery
- Intraoperative use of local anesthesia when patient is undergoing general anesthetic

Assessment

As is commonplace in assessing orofacial pain, the clinician must conduct a holistic evaluation of the patient's pain history, the functional impact, and psychologic consequences of the pain. The area of neuropathy must be qualified within the dermatome distribution of the damaged sensory nerve.¹³⁸ The ipsilateral and contralateral unaffected dermatome should be subject to at least a basic mechanosensory examination recording for the following whether there is sensory gain or loss: Assess the patient's response to light touch (eg, cot-

ton wool), painful stimuli (eg, sharp probe or explorer), and thermal challenge (eg, cold spatula). Visual inspection and palpation should be used to examine for any autonomic changes in color, temperature, sweating, and swelling. Elicited mechanical and thermal allodynia and/or hyperalgesia will reinforce diagnosis of neuropathic pain when there is hyperesthesia rather than a hypoesthetic nerve injury (anesthesia or paresthesia).

There is a role for judicious use of investigations as determined by the presenting patient, their history, and the examination findings. These investigations may include:

- Hematologic tests to exclude systemic causes of neuropathy, including CBC, thyroid function tests, C-reactive protein, autoantibody screen, erythrocyte sedimentation rate, creatinine, alanine transaminase, vitamin B₁₂, ferritin, folate, and serum protein immunoelectrophoresis.
- HbA1c to assess for risk of diabetes or level of glycemic control in patients known to have diabetes.¹³⁹
- Imaging of varying forms such as plain films, computed tomography (CT), or MRI. Most often, local imaging (eg, cone beam CT) or plain films would be indicated if there is a definite history of local damage (eg, mandibular third molar removal or implant placement), but an MRI scan may be indicated if centrally mediated sensory neuropathy is suspected.

Management of posttraumatic neuropathic pain

A recent Cochrane review¹⁴⁰ concluded that there is a lack of high-quality trials to investigate the effectiveness of all forms of management for iatrogenic inferior alveolar and lingual nerve injuries. Thus, management of posttraumatic neuropathic pain is mainly extrapolated from other types of nerve pain.

Most patients present with chronic neuropathic pain mixed with numbness and altered sensation.¹³⁸ The pain the patient is experienc-

ing must be assessed and include the related functional and psychologic impact.¹⁴¹ These aspects must then be managed alongside the pain using psychologic interventions if the patient accepts the important role that psychologic therapies have in managing neuropathic pain. For most patients, it is necessary to use multiple strategies that are tailored to the individual patient's complaint.¹⁴²

The mechanism of injury drives the decision making in and timing of the management of trigeminal nerve injuries. Surgery is urgently indicated for posttraumatic neuropathy related to third molar, implant, or endodontic surgery within 30 hours and rarely up to 3 months but not later.¹⁴² Broad principles for surgical approaches are to immediately repair if nerve section is known and to remove an implant within 24 hours of placement if compression by an implant is thought to be the cause. Surgery is not indicated to explore inferior alveolar nerve injuries older than 4 weeks. Exploratory surgery for lingual nerve injuries must occur within 3 months after injury.^{143–145} Immediate pharmacologic therapy may be indicated alongside surgery for acute sensory nerve injuries. Early management with a corticosteroid taper for 5 to 7 days followed or replaced by 3 weeks of NSAIDs may help reduce the chance of neuropathy following injury.^{146–148} If a painful trigeminal nerve injury has been delayed in its presentation to the consulting clinician, or is not associated with a clear-cut macroscopic trauma amenable to surgery (eg, in PPTN and PDAP), then there may be indications for different pharmacologic therapy. Considerations in the case of delayed painful presentations include topical and systemic pharmacotherapeutic agents:

Topical agents for pain: Topical lidocaine 5% (12 hours on and 12 hours off) should be applied to facial skin away from mucous membranes and eyes.¹⁴⁹ Other compounded off-label topical uses of systemic neuromodulatory agents are also available.¹⁵⁰ Practitioners should be aware of recent concerns about the

lack of preclinical safety studies for such topical medications.¹⁵¹

Botulinum toxin: There is a recent report of two cases using botulinum toxin for PPTN.¹⁵²

Systemic agents for pain: There are guidelines for the medical management of neuropathic pain in adults.^{153–156} The medications used may include selective serotonin-norepinephrine reuptake inhibitors (SSNRIs; duloxetine and venlafaxine), tricyclic antidepressants (amitriptyline or nortriptyline), or anticonvulsants (pregabalin or gabapentin).

Postsurgical neuropathic pain is rare and not well recognized in the field of dentistry. Current management strategies are based on evidence from other neuropathic conditions. Thus, research is needed to provide sufficient evidence with regard to assessment and management of posttraumatic trigeminal nerve injuries.¹⁵⁷

Painful trigeminal neuropathy attributed to acute herpes zoster (ICHD 13.1.2.1)

Chicken pox is caused by the varicella zoster virus. Following the initial infection with the varicella zoster virus, the virus remains dormant in the cell bodies of sensory nerves and may reactivate many years later. This type of reactivation is known as *herpes zoster* (or *shingles* in laymen's terms). The incidence rate of herpes zoster is an estimated 0.03% to 0.05%. Herpes zoster largely affects elderly patients or those with impaired immunity. Symptoms of herpes zoster generally include itching, numbness, or a tingly sensation in the affected dermatome, followed by blisters and pain. Most people heal without sequela in about 3 to 4 weeks, but in a small percentage of people (28.2 to 42 out of 100,000), persistent sensory disturbances or pain may occur.¹⁵⁸ There are now vaccines available to help decrease or prevent herpes zoster in people over the age of 50 years.¹⁵⁹

Management of the acute pain of painful trigeminal neuropathy attributed to acute herpes zoster will be determined by consideration of a number of factors: degree of symptoms, presence of lesions on face or eye, age and immunologic status of the host, and other comorbidities. Antiviral, corticosteroid, and tricyclic antidepressant medications have all been suggested to try and help manage the acute pain and reduce the risk of postherpetic neuropathy.¹⁶⁰ Cochrane reviews, however, cast doubt on the roles of both antiviral and corticosteroid medications in helping prevent postherpetic neuropathy, but they are thought to be beneficial in the management of the acute pain of painful trigeminal neuropathy attributed to acute herpes zoster.^{161,162} Because of the immunosuppressive effect of corticosteroids, they should not be given without antivirals.

Postherpetic trigeminal neuropathy (ICHD 13.1.2.2; ICD-10 B02.22)

Most people heal completely from an episode of herpes zoster within 3 to 4 weeks without any persisting sequelae. However, some people may have irreversible damage to the skin and sensory disturbances. Whereas persisting or recurrent pain is infrequent in the general population, postherpetic trigeminal neuropathy (previously known as *postherpetic neuralgia*) may affect 50% to 75% of the older population who have had herpes zoster, and its incidence varies from 28.2 per 100,000 persons to 42 per 100,000 persons, depending on the country of study.^{158,163} The ICHD describes postherpetic trigeminal neuropathy as unilateral pain developing in temporal relationship to an acute herpes zoster infection that affected one or more branches of the trigeminal nerve and lasting for 3 months or more. The pain usually has a burning character, but there may be superimposed brief, stabbing exacerbations of pain. Postherpetic trigeminal neuropathy may be accompanied by hyperalgesia and allodynia or by profound sensory loss and anes-

thesia dolorosa.¹⁶⁴ Risk factors for developing postherpetic trigeminal neuropathy include female sex, older age, experience of a prodrome, severe rash, and severe pain.¹⁶⁵

The pathophysiology of postherpetic trigeminal neuropathic pain is still largely unknown, but peripheral and central mechanisms have been suggested. Cell destruction at the level of the dorsal horn and loss of cutaneous nerve endings have been implicated.^{166,167} Baron¹⁶⁴ proposed three different types of postherpetic trigeminal neuropathies: one based on peripheral and central sensitization, one based on predominant degeneration of nociceptive neurons, and one mainly based on skin deafferentation. Depending on the type of underlying mechanism, different symptoms may prevail, and different treatment modalities might be more successful. The existence, value, and implications of this differentiation must be further evaluated.

According to a recent systematic review, the anticonvulsants gabapentin (1,800 mg and 3,600 mg per day) and pregabalin (150 to 600 mg per day) show satisfactory pain relief, as does the tricyclic antidepressant amitriptyline (25 to 150 mg per day).¹⁵⁶ Topical lidocaine has also been advocated for treatment of postherpetic trigeminal neuropathy. To date, there are not enough data to support the use of the newer antidepressants in postherpetic trigeminal neuropathy, but if the conventional medications fail or produce too many side effects, a trial of these medications may be indicated. The efficacy of opioids in postherpetic trigeminal neuropathy is as yet uncertain.¹⁶⁸

Painful trigeminal neuropathy attributed to MS plaque (ICHD 13.1.2.4)

Pain can be a common problem in those suffering from MS. The pathophysiology of the pain can be due to either central or peripheral pathology and is often dependent on plaque location. Migraine-type headaches can develop as a consequence of MS or its treatment (ie,

interferon).¹⁶⁹ MS is known for its association with the development of TN, and this is likely to be due to the long-term damage to the trigeminal nerve root entry zone.

MS increases the risk of developing TN by a factor of 20.¹⁷⁰ The nature of TN in MS does not usually differ from classic TN other than being more frequently bilateral. Bilateral TN (14% to 31% in MS) or TN in a young patient may be indicative of underlying MS.^{171,172} TN will precede MS in only 0.3% of patients.¹⁷³ Interestingly, only a minority of patients with MS show vascular compression of the trigeminal nerve root. Decompression procedures on these few specific patients often relieve the neuralgia-like symptoms.¹⁷⁴ Management of this type of pain is the same as that of TN.

Burning mouth syndrome (ICHD 13.10; ICD-10 K14.6)

Burning mouth syndrome (BMS) is defined as “a distinctive nosologic entity characterized by unremitting oral burning or similar pain in the absence of detectable oral mucosal changes” that can last at least 4 to 6 months.^{6,175} Primary or idiopathic BMS (pBMS) has no known cause, so exclusion of causes of secondary burning mouth symptoms is essential to make a diagnosis of pBMS. The array of local and systemic conditions that may produce BMS-like symptoms are listed in Box 6-2.¹⁷⁵

pBMS is a poorly understood pain condition that is most probably neuropathic with both peripheral and central components. Reported prevalence rates of burning mouth symptoms in general populations vary from 0.7% to 15%, with variation likely based on whether a study was a survey or a clinical assessment, the population assessed, and the geographic location under study.^{180–183} Burning mouth symptoms appear most commonly in postmenopausal women—12.2% in the 50-to-69-year age group—and are extremely rare in both men and women under the age of 30 years.¹⁸⁰

Box 6-2 Local and systemic factors thought to be potentially causative for secondary BMS^{176,177}

| | |
|---|---|
| <p>Local factors</p> <ul style="list-style-type: none"> • Alcohol-based mouthwash • Allergy (serum IgE and patch test for dental materials patient is exposed to) • Chewing tobacco use • Ciguatera neurotoxin exposure¹⁷⁸ • Dehydration, mouth breathing, or nasal obstruction • Gastric reflux¹⁷⁹ • Infection (bacterial, fungal, viral) • Mechanical (trauma or reduced tongue space from poorly fitting prostheses) • Oral lesions: erosive lichen planus; geographic tongue; leukoplakia, neoplasia, pemphigoid; pemphigus; vesiculobullous conditions • Parafunctional habits • Stomatitis: allergy-induced, aphthous, radiation-induced • Xerostomia (salivary flow rate) | <p>Systemic factors</p> <ul style="list-style-type: none"> • Autoimmune conditions (Sjögren syndrome) • Endocrine: diabetes mellitus (HbA1c), hypothyroidism (thyroid function tests), menopause • <i>Helicobacter pylori</i> (antibodies to <i>H pylori</i>) • Medication (eg, angiotensin-converting enzyme inhibitors, angiotensin II receptor blockers, antiretrovirals, psychotropic, anticholinergic, clonazepam, chemotherapeutic agents) • Neuropathy: nutritional neuropathy (check serum ferritin, vitamins B₁, B₆, B₁₂, folate, and zinc); peripheral neuropathy due to systemic disease (eg, HIV, sarcoidosis, MS) |
|---|---|

Ig, immunoglobulin.

Examinations should reflect those undertaken for peripheral neuropathies and conditions listed earlier in the chapter. If any of the factors listed above are discovered to contribute to the burning mouth symptoms, then a diagnosis of secondary BMS should be made.

The condition has also been known as *stomatodynia*, *glossodynia*, or *stomatopyrosis* and is characterized by a burning sensation in the mucosa despite the absence of clinical examination findings; pBMS would also have no abnormalities identified in laboratory testing or imaging.

The burning pain commonly presents with a bilateral symmetric distribution, with the most frequently affected areas including the anterior two-thirds, dorsum, and lateral borders of the tongue; the anterior hard palate; and the mucosa of the lower lip; it often occurs in more than one oral site.^{184,185} Onset often appears to be spontaneous in around 50% of patients; however, 17% to 33% of patients may attribute the onset of pain with an upper respiratory tract infection, a previous dental procedure, or med-

ication use (including antibiotics).^{183,186} Others report that onset of symptoms occurred following traumatic life stressors.¹⁸⁶ Symptoms may be continuously present for significant periods of time (months to years) without cessation or remission, and only a small number (3% of patients within 5 years of onset) demonstrate complete remission.¹⁸⁷ Burning is usually a constant daily phenomenon, and around one-third of patients experience symptoms both day and night.^{180,184} Most patients report minimal symptoms on awakening, after which the symptoms crescendo through the day toward the evening. A large proportion of patients experience intensification of the burning related to presence of personal stressors and fatigue or eating acidic, hot, or spicy foods. Equally, however, a proportion report reduction

or alleviation of burning through oral intake or stimulation and distraction.¹⁸⁸

pBMS is associated with many possible factors including anxiety, depression, and personality disorders, particularly in postmenopausal women, but it is unclear if pain initiates the psychologic disorder or vice versa.^{175,180,189,190} Approximately 21% of pBMS patients present with significant psychologic distress, but pBMS patients show no evidence of significant clinical depression, anxiety, and somatization.¹⁹¹ Moreover, pBMS patients report less interference in their daily activities than other chronic pain patients.¹⁹¹

There are various regional and local phenomena that have been associated with pBMS. These include reduced parotid gland function and altered salivary composition.^{192,193} pBMS patients generally exhibit greater vaso-reactivity, suggesting involvement of the autonomic nervous system.¹⁹⁴ Evidence supports two theories: a neuropathic imbalance between the gustatory and sensory systems or a peripheral and/or central sensory neuropathy. A role for some form of neuropathy in pBMS seems likely given that varying somatosensory changes (gain or loss) have repeatedly been identified in patients with pBMS.^{195,196}

It is thought that inhibitory influences between the gustatory and sensory systems help to maintain a sensory balance in the tongue. Hypothetically, therefore, disruption in this equilibrium through altered chorda tympani dysfunction could then lead to lingual nerve hyperfunction and a neuropathic-based burning sensation. The role of an imbalance between the gustatory (chorda tympani or glossopharyngeal) and sensory systems (lingual or glossopharyngeal) is uncertain, especially given that grey matter changes are present in the pain matrix of those with BMS as opposed to dysgeusia, but there are data supporting interplay between sensory and gustatory trigeminal pathways.^{197–199} Further studies are needed to elucidate this complex and putative relationship.

pBMS may result not only from hyperactivity of the sensory component of the trigeminal nerve following loss of central inhibition but also from damage to the chorda tympani.^{200–203} This damage results in reduced inhibition of the trigeminal nerve that in turn leads to an intensified response to oral irritants and eventually to neuropathic pain. The exact mechanisms and interactions, however, are obscure, and the evidence is unclear.

A sensory neuropathy is suggested by findings that the sensory threshold in the tongue was significantly higher in patients than in controls.^{204,205} pBMS patients have a significantly lower density of epithelial nerve fibers in the anterior two-thirds of the tongue, with some correlation to symptom duration.^{206,207} Experimental evidence suggests the existence of several diagnostic BMS-neuropathy subgroups, including peripheral neuropathy and centrally mediated pain.^{198,208–212} Studies examining the identification of a predominantly peripherally driven BMS as opposed to a predominantly centrally driven BMS have used a lingual block to make this determination. They have demonstrated that topical medication, specifically clonazepam, is more effective in those with a peripherally driven BMS and that its therapeutic effect may be mediated by γ -aminobutyric acid A (GABA_A) receptors present on peripheral afferents in the tongue.^{213,214}

Management options for pBMS are limited because of the incomplete understanding of the etiology and pathophysiologic processes for this disorder. Current treatment approaches include the following, which can be combined²¹⁵:

- Cognitive behavioral approaches
- Topical management using analgesics, anxiolytics, artificial sweeteners, and low-level laser therapy
- Systemic management using antidepressants, anticonvulsants, and atypical analgesics or antipsychotics

One of the most intensively investigated pharmacologic agents for BMS is clonazepam, for which there are meta-analysis data supporting its efficacy both systemically and topically.²¹⁶ A recent clinical evidence update suggests that cognitive behavioral therapy is likely to be beneficial and that there is a trade-off between risks and benefits with the use of clonazepam, given its potential for dependency.²¹⁷ The same review suggests that α -lipoic acid, benzydamine hydrochloride, selective serotonin reuptake inhibitors (SSRIs), and tricyclic antidepressants are of unknown effectiveness.

Central Neuropathic Pain (ICHD 13.12)

This new category in the ICHD is subdivided into central neuropathic pain attributed to MS and central poststroke pain (CPSP).

Central neuropathic pain attributed to MS (ICHD 13.12.1)

Pain is a frequent symptom in MS and may have a variety of potential mechanisms, including pain resulting from the disease process, but also pain as a result of the disability.²¹⁸ Any lesion from the spinal dorsal horn or spinal trigeminal nucleus to the cerebral cortex can cause central neuropathic pain attributed to MS.

Neuropathic pain in MS shares the generic features of neuropathic pain as previously described. This pain may be episodic or constant, although constant pain is more typical. With the exception of some of the stereotyped manifestations (such as TN, optic neuritis, or painful tonic spasms), the clinical features of the neuropathic pain in MS are often not specific for site of lesion or the underlying pathology. Anecdotal, central neuropathic pain affecting the face and head attributed to MS is much less

frequent than TN. Diagnostic pointers for central neuropathic pain attributed to MS include evidence of CNS disease, distribution of pain (sometimes regional or cranial nerve or occasionally root), and the presence of other neurologic symptoms or signs (mostly sensory).

Central poststroke pain (ICHD 13.12.2; ICD-10 G89.0)

CPSP is characterized by unilateral facial or head pain, dysesthesia, and impaired sensation to pinprick and temperature that occurs within 6 months of a stroke and is not due to a lesion of the trigeminal nerve (with imaging demonstrating a lesion in an appropriate site). CPSP is attributed to a lesion somewhere along the spinothalamic pathway and by definition is the result of a vascular lesion (eg, ischemic or hemorrhagic infarction). The pain is not limited to the facial and cranial area; similar symptoms may be experienced in the entire half of the body contralateral to the infarction (such as after a thalamic stroke). Similar pain can be produced by lesions that involve the ascending pain pathways elsewhere in the CNS, and the term *central pain* is used to indicate such involvement.

Few RCTs investigating treatment modalities for CPSP have been performed. A 2006 systematic review identified amitriptyline and lamotrigine as the most effective medications, followed by mexiletine and phenytoin.²¹⁹ Carbamazepine did not appear effective, whereas gabapentin, although promising, was not studied sufficiently. This review also indicated that intravenous ketamine, propofol, and lidocaine might be helpful for short-term treatment. Invasive procedures may have a place when pharmacologic management fails. The available data are mostly anecdotal but suggest that deep brain stimulation and cortical stimulation may be helpful.²²⁰

Neurodegenerative Diseases as Causes for Central Pain

There is a growing awareness that neuropathic pain can be an important feature of neurodegenerative conditions.²²¹ This has been perhaps best defined in Parkinson disease, a degenerative neurologic disorder with motor and nonmotor features. Pain is a common symptom in patients with Parkinson disease.²²² This includes primary pain (ie, central pain arising from the CNS) and secondary pain (eg, pain arising from the musculoskeletal system). Central pain in Parkinson disease is estimated to have a prevalence of 10% to 12%.²²² Central pain is recognized in a number of different areas including the mouth, rectum, vagina, abdomen, chest, and testes. Fil et al²²² have reviewed pain in Parkinson disease and propose that it might result from pathologic changes in structures involved in the nociceptive system. In some patients, this pain might respond to dopaminergic therapy, but conventional analgesics and tricyclic antidepressants are recommended otherwise.

Tolosa-Hunt syndrome (ICHD 13.7; ICD-10 H51.9)

Tolosa-Hunt syndrome is characterized by episodes of orbital pain accompanied by paralysis of one or more of cranial nerves III, IV, or VI. One or more of these nerves will contain lesions caused by granulomatous inflammation of superior orbital fissure, cavernous sinus, or orbit as demonstrated by MRI or biopsy. As with any painful ophthalmoplegia, other differential diagnoses should be considered, including vasculitis or vascular, neurologic, inflammatory, infiltrative, or space-occupying processes, such as pseudotumor of the orbit, temporal arteritis, and ophthalmoplegic migraine.²²³ Episodes are said to have a duration of 8 weeks in untreated patients; patients experience relief of pain within 72 hours of initiation of corti-

costeroid therapy. If suspected, referral to an ophthalmologist is suggested.

CRPS (no ICHD category; ICD-10 G90.50)

CRPS is a term that has been coined to replace two different disorders of the autonomic nervous system. CRPS 1 has been proposed to replace the term *reflex sympathetic dystrophy* (ICD-10 G90.59), and CRPS 2 has been proposed to replace the term *causalgia*, also described as *mononeuritis* (ICD-10 G58.9). The replacements have not been widely accepted, and the older terms are still frequently used.

According to the IASP, CRPS is characterized by persistent, often burning pain accompanied by allodynia and hyperalgesia and at some point accompanied by swelling, changes in blood flow, and/or abnormal sudomotor activity.⁶ In CRPS 1, the symptoms occur after a mild injury and are disproportionate to the initiating event, whereas in CRPS 2, there is evidence of nerve damage preceding the persistent pain. A 2007 revision to the IASP criteria has been proposed.²²⁴ The criteria include four symptom categories, of which at least three must be reported and at least two must be present at the time of evaluation. The four categories consist of sensory, vasomotor, sudomotor/edema, and motor/trophic changes. The distinction between CRPS 1 and CRPS 2 was maintained, and a third diagnosis, *CRPS not otherwise specified*, was added for patients not fully meeting the criteria.

The pathophysiology of CRPS remains unclear, and it may be peripherally or centrally mediated and of neuropathic, inflammatory, or immunologic origin.²²⁵ Estimates of the incidence of CRPS range between 5 and 26 cases per 100,000 persons.^{226,227} Women are afflicted about three times more often than men.²²⁷ CRPS is typically found in the upper or lower extremities, with the upper extremities more often involved than the lower extremities, and it is not generally described as occurring in the head and neck. A review of the

available literature between 1947 and 2000 identified only 13 cases with head and neck involvement.²²⁸ The typical features, such as loss of function and skin atrophy, were rarely seen, and therefore the diagnoses in most of these cases were debatable.

In some cases of CRPS, the peripheral nociceptors become sensitive to adrenergic stimulation. In those cases, any increase in activity of the sympathetic nervous system is likely to increase the pain experience. Increased levels of emotional stress and even visual or auditory stimuli can markedly increase the pain intensity. Typically, this pain is responsive to sympathetic blockade, and in such cases, the term *sympathetically maintained pain* is appropriate. Studies trying to resolve which features (eg, mechanical allodynia, cold allodynia) might predict a favorable response to sympathetic blockade have shown contrasting results.^{229–231} High anxiety levels, litigation, and disability may be related to poor treatment response to a sympathetic blockade.²³¹

Treatment of CRPS generally includes physical rehabilitation, psychologic interventions, and pharmacologic management.^{225,232} Few RCTs with adequate sample sizes are available with regard to the treatment of CRPS, and no particular pharmacologic or intervention strategy appears to stand out. Therefore, at this time, pharmacologic treatment should follow the treatment paradigms for neuropathic pain. In the case of sympathetically maintained pain, a series of sympathetic blocks is indicated.²³³

Persistent idiopathic facial pain (ICHD 13.11; ICD-10 G50.9)

This category has historically been referred to as *atypical facial pain*. It is a term that when applied essentially means that no absolute mechanism or characteristics can be determined that allow the presenting pain to be assigned to any other diagnostic category. It may or may not belong in a neuropathic pain classification given the wide variation in its pre-

sentation as only some of this continuum represents potential neuropathy.²³⁴ The incidence of persistent idiopathic facial pain is estimated at 4.4 per 100,000 person-years, and lifetime prevalence is estimated at 0.03% with a predilection for presenting in middle-aged to older women.^{195,235,236}

The current ICHD suggests that persistent idiopathic facial pain can only be diagnosed when pain is present for more than 3 months, occurring daily with episodes of pain lasting for greater than 2 hours, in a poorly localized manner, and following an unrecognized dermatome pattern. Its character is described as a dull aching, nagging quality, but it can have acute exacerbations, with one of the aggravators being stress. It may present with psychiatric comorbidity and significant psychosocial disability. Prior to the diagnosis, all other local or systemic causes and intracranial causes (eg, intracranial mass lesions) must be excluded. This may require additional assessment by an otorhinolaryngologist and/or a neurologist. In the process of evaluating potential other types of underlying pathology, hematologic and imaging investigations may be necessary, including an MRI of the head and/or face to exclude intra- and extracranial causes of the pain. QST may also be of benefit to determine if there are any neuropathic elements contributing to the overall pain picture of persistent idiopathic facial pain.¹⁹⁵

Because there are no RCTs that include large samples of patients with persistent idiopathic facial pain, treatment typically relies on therapies proven successful in studies for other persistent orofacial pains predominantly using cognitive behavioral therapy and/or any of the following therapeutic agents: tricyclic antidepressants, SSNRIs, gabapentin, and pregabalin.^{237,238}

Occlusal dysesthesia (phantom bite/occlusion)

Patients with occlusal dysesthesia (OD) present with a primary complaint of an uncomfortable

and/or incorrect occlusion, usually accompanied by emotional distress.^{239,240} Even though this is largely unverifiable, OD patients are convinced of the validity of their complaints and the belief that mechanical and/or surgical dental interventions will accomplish correction.²³⁹ Repeated and failed treatments by clinicians serve to reinforce the patient's potentially hypervigilant state in respect to the occlusion and/or that something is seriously wrong with the occlusion.^{241–245} Clinicians often pursue a course of multiple occlusal readjustment appointments, which usually results in increasingly distressing symptomatology reported by the patient. Reassurances that the patient suffers from no occlusal problems usually induce further distress.

The onset of OD can occur at any stage of dental treatment. However, patients typically associate the origin of phantom bite syndrome with the construction of extensive dental prostheses.²⁴⁶ OD is observed in all age groups with no clear sex predilection; adolescents undergoing orthodontic treatment may also experience OD.^{239,247} OD is usually painless; when pain accompanies OD in patients with a history of extractions or multiple surgical interventions, an additional diagnosis of peripheral painful traumatic trigeminal neuropathy should be considered. Patients with OD may describe the need for repositioning of the mandible (often protrusion) to obtain some relief. Further complaints may include the feeling that the tongue is too big or disturbed sensations in the gingiva.²⁴⁰

Whether OD is a neuropathic disorder is debatable. Originally, patients with OD were considered to be suffering from a form of monosymptomatic hypochondriacal psychosis, which is an uncommon psychiatric disorder characterized by a single delusion as the sole symptom.^{239,248} Although OD cases are often characterized by a number of psychosocial disorders, current thinking links the initiating pathophysiology to physical components.^{246,249,250} The first possibility is occlusal hyperawareness or iatrogenic dysproprioception.²⁵¹ Following changes

in the dental occlusion, it is necessary to adapt to or relearn new jaw movements and proprioception. Patients with OD suffer because they are unable to adapt to even small changes in the dental occlusion. Additionally, patients with OD may become distressed by the lack of familiarity of their own bite. This is based on the theory that the sensation derived through tooth contact acts as a self-identifier.^{240,248} In other words, when placing one's teeth together, one confirms the "self." A further possibility is that when tissue damage (apicoectomies, extractions, implants) has formed part of the initiation of OD, the pathophysiology may be due to neuropathic mechanisms, as occurs in traumatic neuropathy.²⁴⁰ Peripheral painful traumatic neuropathy may present with disturbed proprioception, allodynia, and pain, explaining the symptomatology of OD.¹⁸ In many ways, it is similar to the "phantom pain" described by amputees—hence the original term *phantom bite*.

Pain in OD may arise from comorbid traumatic neuropathy, and this should be treated accordingly. Comorbidity of OD with TMDs has been reported, and although successful therapy of the TMD does not alleviate symptoms of OD, it improves the patient's quality of life.^{246,252} Treatment of OD itself is difficult—any further attempts to "equilibrate" the occlusion or grind down specific areas that bother the patient will usually lead to no improvement or worsening of symptoms.²⁵³ Based on case reports, the use of acrylic guards does not relieve OD symptoms.²⁴⁶ In a small case series, the use of milnacipran, an SSNRI, improved OD symptoms in five out of six patients.²⁵⁴ A psychiatric consultation or a psychologic assessment is a specific consideration. A combined approach beginning with a behavioral medicine consultation and initiation of SSNRI therapy is recommended. A serious attempt must be made to demonstrate the futility of any further interventions, and patients should be encouraged to adopt a coping approach, incorporating relaxation and cognitive behavioral therapy.^{245,255}

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Intraoral Pain Disorders

Key Points

- ◇ Pain (both acute and chronic) in the oral cavity and adjacent craniofacial structures is a common complaint in both healthy and medically complex patients.
- ◇ Diagnosis of oral pain can be complicated by referred or radiating pain and by proximity of multiple afferent nerve fibers.
- ◇ Even though painful conditions of various etiologies may overlap, there are typically distinguishing features that will direct the clinician to the correct diagnosis.
- ◇ Dental and periodontal pains generally have an infectious or inflammatory etiology but in rare instances may have systemic or extraoral causes.
- ◇ Mucosal (soft tissue) oral pain has a more varied etiology, with traumatic, viral, fungal, autoimmune, and iatrogenic causes predominating.

Odontogenic Pain

Pain described by the patient as “toothache” may occasionally confound the clinician during the diagnostic process because perception of tooth sensitivity can be experienced due to dental disease, or it can arise in other tissues, either adjacent to the tooth or anatomically distant (ie, referred pain). Similarly challenging may be the fact that dental pathology may refer pain to other teeth or distant locations in the maxillofacial area or the neck, which can mimic other types of facial pain. In addition, regional pain from adjacent structures, other orofacial pain disorders, and distant disease such as central nervous system (CNS) lesions (eg, tumors) may refer pain to teeth and mimic the symptoms of toothache. Whereas

the origin of most dental pain can be easily located, the clinician must be aware of these other possibilities, which become more likely with chronic, intractable symptoms.

As a first step in the diagnosis process, the clinician must determine if the pain is truly odontogenic in origin. If it can be attributed to dental disease, it is then necessary to determine if the pain is of pulpal or periodontal origin (or both). Nonodontogenic sources of pain that may mimic toothache are reviewed at the end of this chapter, and the codes from *The International Classification of Diseases, Tenth Edition (ICD-10)* are presented for each disorder.

Pulpal pain (ICD-10 K04.0)

The dental pulp is a visceral tissue, and pain that originates there has characteristics similar to other types of visceral pain, which tend to be deep, dull, or aching pain that is of a threshold nature and that may sometimes be difficult to localize.¹ Pulpal pain can arise only from vital teeth with functioning nerves. In these teeth, pain may arise from *pulpitis*, which is reversible or irreversible inflammation of the tissue.

Reversible pulpitis

Reversible pulpitis is characterized by a short, sharp, hyperalgesic response that subsides soon (ie, seconds) after the stimulus is removed. The pain must be provoked and typically does not occur spontaneously. Irritants such as hypertonic solutions (eg, sugary food) or thermal extremes may cause focal stimulation, which produces a brief pain.² It is worth noting that pain from reversible pulpitis is a symptom, not a disease process.

Irreversible pulpitis

Irreversible pulpitis is characterized by prolonged pain, either spontaneous or provoked by a stimulus. This type of pain tends to be variable and may be intermittent or continuous, moderate or severe, sharp or dull, local-

ized or diffuse, and affected by the time of day or body position. The intensity of the pain may also vary over time, and the tooth may go through asymptomatic periods. Pulpal inflammation is typically more severe and more widespread than in reversible pulpitis, and it may progress to pulpal necrosis.²

Nonvital tooth pain

Pulpal necrosis (*ICD-10 K04.1*) results from untreated pulpitis, exposure of the pulp to oral bacteria, traumatic injury, or other events that cause long-term interruption of the blood supply to the tissue. Pulpal necrosis may be partial or total. Partial necrosis may have some of the symptoms associated with irreversible pulpitis, which is common in multirooted teeth. Total necrosis is asymptomatic as long as no other disease process (ie, infection) affects the adjacent innervated tissues.² If pulpal disease extends beyond the apex of the tooth, pain becomes both spontaneous and continuous and can be exacerbated by percussion but not by temperature changes.

Etiology of pulpal pain

Tooth sensitivity may occur when dentinal tubules are exposed to the oral environment, causing fluid movement that affects the pulp.^{3,4} Attrition (*ICD-10 K03.0*), abrasion (*ICD-10 K03.1*), abfraction, erosion (*ICD-10 K03.2*), dental caries (*ICD-10 K02.9*), gingival recession (*ICD-10 K06.0*), toothbrush trauma, periodontal diseases (*ICD-10 K05.30*), or periodontal surgery may expose coronal and/or radicular dentin. The factors leading to acute pulpal pain can be grouped into three general categories: bacterial, traumatic, and iatrogenic.

Bacterial. Bacteria or their metabolic byproducts are introduced into the pulp as a result of dental caries, inadequate restorations, enamel and/or dentin fractures, or anomalous tracts from the periodontium or from the systemic blood supply (bacteremia and retrograde infection).⁵⁻¹¹

Traumatic (ICD-10 K03.8). Direct trauma to a tooth can cause pulpitis, acute pulpalgia, incomplete fracture, or complete fracture with exposure of dentin or the pulp.⁷ Trauma may subluxate or completely avulse a tooth, with consequent disruption of the apical blood supply and subsequent pulpitis or necrosis.¹² Repeated microtrauma, such as chronic awake or sleep bruxism, may also cause pulpal inflammation or impact the blood flow to the pulp, which may lead to necrosis.

Iatrogenic. The process of restoring teeth may cause pulpitis and acute pulpalgia. Heat and vibration from dental procedures, depth of preparation, dehydration of dentin, insertion of pin-retained restorations, and accidental pulp exposure have been well documented. Pulpal changes have also been reported following impressions in which bacteria were forced through the dentinal tubules. Furthermore, many dental materials and chemicals have the potential to irritate or injure the pulp.

Pathophysiology of pulpal pain

Myelinated (A δ) and unmyelinated (C) afferent nerve fibers innervate the dental pulp. The A δ fibers arborize in the coronal part of the tooth, just below the odontoblasts, where they lose their myelin sheath and form the plexus of Raschkow.^{4,13} This plexus sends free nerve endings onto and through the odontoblastic cell layer, where they contact the odontoblastic processes at the pulpal end of the dentinal tubule.¹⁴ The intimate association of A δ fibers with the odontoblast is referred to as the *pulpo-dentinal complex*.¹⁵ If the cellular or fluid contents of the dentinal tubules are sufficiently disturbed to involve the odontoblastic cell layer, the A δ fibers become excited.^{16–18} These nociceptive signals are perceived as sharp (bright), momentary pain that resolves when the stimulus is removed.¹⁵ If an external irritant is of significant magnitude to cause pulpal inflammation, a vascular response (hyperemia) can lead to an increase in tissue pres-

sure (perceived as pain), which increases as inflammation increases.¹⁹

A tooth with localized inflammation can also produce A δ fiber pain with other types of excitation. Inflammatory mediators such as bradykinin, 5-hydroxytryptamine (5-HT, also known as *serotonin*) and prostaglandin E2 can sensitize the A δ fibers, heightening their response to stimulants. As exaggerated A δ fiber pain subsides, a dull throbbing ache remains, associated with inflammatory involvement of nociceptive C-fibers.¹⁵ This type of pain occurs with more severe tissue injury and is modulated by chronic inflammatory mediators, vascular changes in blood volume and blood flow, and increases in intrapulpal pressure. When C-fiber pain dominates over A δ fiber pain, the symptom is more diffuse and poorly localized and may be referred to other sites. C-fiber pain typically signifies irreversible tissue damage as the inflammation increases.¹⁵ Pain may begin as a short, lingering discomfort, which can escalate to intense, prolonged episodes or constant, throbbing pain. When a caries lesion contacts the pulp, the cellular inflammatory response changes from mostly mononuclear to polymorphonuclear leukocytes (neutrophils), resulting in microabscesses within the inflammatory lesion, at which point pulpitis typically becomes irreversible.^{20–22} Complete necrosis of the pulp may occur rapidly, or it may take years to develop; symptomatology covers the spectrum from severe pain to complete analgesia.

Clinical characteristics of pulpal pain

Pulpal pain usually presents as a visceral, deep, dull, aching sensation.²² This pain may be superimposed with pulsing and throbbing, or it may be sharp, burning, and lancinating due to local nerve sensitization rather than to vascular or neuropathic mechanisms. Clinical symptoms correlate poorly with the histologic status of the pulp.^{23–25} Severe pain may be associated with early histopathologic changes, while a tooth that is asymptomatic may be necrotic. Pulpal pain can be modified by many

factors including heat and cold, pressure from occlusal contacts, head position, and the intensity of the offending stimulus. In addition, pain perception is complex and is affected by pain signaling, the patient's emotional state, and sociocultural background.⁴

When the pain is referred, it tends to follow a laminated segmental pattern within the trigeminal system. Maxillary teeth commonly refer pain to maxillary and mandibular teeth on the same side and to cutaneous locations on the face, superior to the maxillary teeth. Mandibular teeth tend to refer pain to maxillary and mandibular teeth on the same side. Anterior teeth may refer pain to both sides of the face.^{26–28} Cutaneous referral patterns start at the level of the ear and project to locations on the face inferior to the ear.

Differential diagnosis of pulpal pain

The first step in the diagnostic process is to determine whether the patient with a toothache is experiencing pain from an odontogenic or a nonodontogenic source. The tooth causing the odontogenic pain is usually identified by the presence of pathology to explain the pain (eg, caries or large restoration, combined with historic, clinical, and radiographic findings).²⁹ When a suspicious tooth is located, diagnosis may be confirmed by increased pain on application of a noxious stimulation (chemical, thermal, mechanical, or electric sources). If the pain can be influenced by local irritation, the tooth should be anesthetized to determine if the pain is blocked. If local anesthesia has no effect, pain from a nonodontogenic source should be considered. If administration of anesthesia decreases but does not eliminate the pain, there may be an additional nonanesthetized contributor to the pain.

Once a conclusion regarding the source has been reached, the next step is to determine if the pain is pulpal or periodontal in origin. Pain of pulpal origin tends to respond to a stimulus at a given threshold and may be difficult to localize. Teeth that have only pulpal involvement are

generally not sensitive to percussion. Teeth that have periodontal and/or periapical involvement typically respond to percussion or pressure on a graduated basis, and the pain is easier to localize.²⁹ Reversible pulpitis is characterized by stimulated pain of brief duration that ceases seconds after removal of the stimulus. Cold and electric stimulation provoke a brief response, and sensitivity to percussion is uncommon.²⁹ Irreversible pulpitis is characterized by stimulated pain of prolonged duration and/or by spontaneous pain. There may be no sensitivity to percussion until the inflammatory process extends to the periapex.²⁹ A necrotic pulp is asymptomatic until it becomes infected and inflammation extends to periapical tissues. The tooth is not responsive to either cold or electric pulp testing; however, there may be extreme sensitivity to percussion if the periapex is inflamed.²⁹

Management considerations for pulpal pain

Treatment for dentin sensitivity is directed at reducing fluid movement in the dentinal tubules. Treatment modalities include (1) formation of a smear layer on the sensitive dentin by burnishing the exposed surface; (2) application of agents such as oxalate, arginine, or peptides that form insoluble precipitates within the tubules; (3) impregnation of the tubules with plastic resins; and (4) application of dentin bonding agents to seal the tubules.^{30–33}

Treatment for reversible pulpitis targets removal of the pain-causing stimulus, such as caries, and restoration of lost tooth structures. Treatment of irreversible pulpitis or a necrotic pulp requires root canal therapy or extraction of the tooth. Systemic antibiotics are contraindicated when disease is localized to the pulp. A necrotic pulp is devoid of blood circulation, so no systemic medication will penetrate the space.

Acute periodontal pain

The periodontium (ie, periodontal ligament and alveolar bone) is of mesenchymal origin. Therefore, periodontal pain tends to be

more localized in comparison to visceral pain of pulpal origin. Localization of the source of pain is attributed to the proprioceptive and mechanoreceptive sensation of the periodontium.³⁴ Periodontal pain is generally dull and aching. Inflammatory fluid may cause displacement of the tooth in the socket with a resulting acute malocclusion and typical localization of the pain with biting or chewing. The diseased site readily responds to provocation proportionate to the stimulus.¹ At minimal levels of stimulation, the patient may describe an innocuous sensation such as itching or moderate dull aching; at severe levels, the patient may describe unrelenting, aching, and throbbing pain. Factors that may increase periodontal pain include occlusal contact, head position, the intensity of the stimulus, and CNS modulation. Periodontal pain, like pulpal pain, may stimulate secondary central excitatory activity, resulting in regional pain referral around the head and neck, to muscle overload with the potential to develop myofascial trigger points, and to autonomic effects such as sinus congestion, conjunctival injection, and eyelid edema or drooping. Sites of prior pain are more likely to be sites of referred pain. Periodontal pain localized to a single tooth is usually associated with a gingival or periodontal abscess or a combined periodontal-endodontic lesion.³⁵

Gingival abscess (ICD-10 K05.00)

Clinical characteristics. The gingival abscess is a relatively rare entity. It usually arises as a result of foreign body impaction or trauma to previously healthy tissue and is confined to the marginal gingiva. It presents as a painful, possibly fluctuant swelling. The surface may be erythematous, smooth, and shiny. Spontaneous drainage may occur.³⁶

Etiology. The precipitating cause of a gingival abscess is usually an impacted foreign object (eg, popcorn kernel) or trauma followed by infection.

Pathophysiology. The gingival abscess consists of a purulent focus in the connective tissue surrounded by an inflammatory infiltrate.

Management considerations. Treatment is by incision and drainage, followed by oral rinses with warm salt water, and may require removal of the causative agent. On rare occasions, irrigation and debridement of the soft tissue lesion may be required.

Periodontal abscess (ICD-10 K05.20)

Clinical characteristics. Periodontal abscesses arise as acute or recurrent inflammatory swellings in periodontally diseased dental sites. The classic periodontal abscess is a localized swelling of the gingiva and/or the alveolar mucosa. These lesions often have an erythematous, violaceous, or cyanotic appearance and may be fluctuant. Pain is variable and can range from a deep ache of low intensity to severe discomfort. The pain is often exacerbated by chewing and percussion. The affected tooth may be mobile and may be slightly extruded. Fever and malaise may occur in more severe cases, cases of cellulitis, and systemic symptoms with lymphadenopathy.³⁶⁻³⁹ Suppuration may be noted from the pocket orifice. The tooth is usually vital.^{36,37}

Etiology. The infectious cause of the lesion is the periodontal microbial flora, which is usually composed of pathogens such as *Porphyromonas gingivalis*, *Prevotella intermedia*, *Fusobacterium nucleatum*, *Peptostreptococcus micros*, and *Bacteroides forsythus*.⁴⁰⁻⁴² It may arise from chronic periodontitis that cannot drain into the periodontal pocket or from trauma or extension of pulpal inflammation into the periapical tissues.^{29,43} A lateral pulp canal may also cause an abscess in the periodontal space, which technically is not a periodontal abscess and requires root canal therapy.

Pathophysiology. A periodontal abscess is usually an exacerbation of a preexisting chronic

periodontal condition. More than 300 species of microorganisms have been isolated from periodontal pockets, but only a small number are considered pathogenic.⁴⁴ Most of the tissue destruction found in established periodontal lesions is a result of the mobilization of the host immunity via activation of monocytes, lymphocytes, fibroblasts, and other host cells. Engagement of these cellular elements by bacterial factors, in particular bacterial lipopolysaccharide, is thought to stimulate production of both catabolic cytokines and inflammatory mediators including arachidonic acid metabolites such as prostaglandin E2. Cytokines stimulate inflammatory responses that cause tissue destruction via activation of tissue metalloproteinases, a major pathway for connective tissue attachment loss and bone loss in most forms of periodontitis.^{45–47}

Management considerations. Treatment consists of establishing drainage (usually through the pocket orifice) and debridement of the root surface and pocket wall under local anesthesia, accompanied by copious irrigation. Occlusal adjustment is sometimes indicated. Unless the tooth is beyond salvage, it is usually prudent to resolve the symptoms and then reassess the periodontal status. The endodontic status (ie, vitality) of the tooth should also be determined.

Periradicular (periapical) abscess (ICD-10 K04.7)

Clinical characteristics. Pulpal infection may induce an inflammatory reaction that may lead to periradicular abscess formation. Clinical characteristics include rapid onset; spontaneous pain; and acute response to percussion, purulence, and swelling.² It must be distinguished from the periodontal abscess, although both processes may be operant in the case of a combined periodontal-endodontic lesion. One helpful element for differentiation is that the periodontal abscess occurs in a setting of periodontal attachment loss and pocket formation. The initial pain associated with a

radicular abscess is intense when confined to bone, and it subsides following formation of a fistulous tract (drainage) into the soft tissues. The infection may drain in the oral cavity or spread along fascial planes and result in cellulitis. In addition, bacteremia may occur, resulting in systemic infection. If the infection localizes, it may progress to a fluctuant swelling that may eventually drain.

Etiology. A periradicular abscess usually develops from a necrotic pulp that becomes infected, with spread of infection into the periradicular tissues.¹⁴ Occasionally, it may develop from exacerbation of chronic periodontitis located near the tooth apex (called *phoenix abscess*).

Pathophysiology. The periradicular abscess is initiated by infiltration of bacteria into the apical periodontal ligament from an infection in the pulp, causing an acute inflammatory reaction.

Management considerations. Management involves treating the cause of the abscess, which is endodontic (root canal therapy), or extraction of the offending tooth. Spread of the infection may require drainage of exudates and/or systemic antibiotics. Signs and symptoms such as fever, swelling of the infraorbital region or other spaces due to extension along fascial planes, trismus, stridor, elevation of the floor of the mouth, or neck tracks may indicate significant danger and typically require urgent intervention. In such cases, oral antibiotics are insufficient, and the patient should be immediately referred to a hospital.

Pericoronitis (ICD-10 K05.20)

Clinical characteristics. Pericoronitis is a localized infection within the soft tissue that surrounds the crown of an impacted or partially erupted tooth, most commonly a third molar. Clinical features may include an erythematous, swollen, suppurating gingival lesion that is tender and may cause radiating pain to the ear, throat, and floor of the mouth. The patient may

experience a bad taste and inability to open or fully close the jaws. Swelling of the cheek in the region of the angle of the mandible is common, as is lymphadenopathy. The patient may also experience signs and symptoms of systemic complications such as fever, leukocytosis, and malaise.

Etiology. The typical process involves bacterial colonization of the pericoronal space, which triggers inflammation. Food debris or foreign objects may also become trapped under the gingival tissue covering the crown, thereby contributing to the inflammatory process.

Pathophysiology. Streptococci are common in the oral cavity and can produce hyaluronidase, which makes these organisms the typical cause of pericoronitis. Cellulitis may follow the spread of the infection posteriorly into the oropharyngeal area and medially to the base of the tongue, making it difficult for the patient to swallow. Depending on the severity of the infection, lymph node involvement of the submandibular, posterior cervical, deep cervical, and retropharyngeal regions may occur.⁴⁸

Management considerations. An irrigating syringe should be used to perform lavage under the gingiva with sterile saline or chlorhexidine solution. Removal of the tooth is generally indicated when the acute episode has resolved. Removal of the operculum is sometimes advocated in lieu of extraction; however, the soft tissue frequently regrows, resulting in the same local conditions that lead to infection. Abscess formation is common and leads to the need for surgical drainage and appropriate antibiotic therapy. Patients presenting with trismus, fever greater than 101°F, and facial swelling are candidates for referral to an oral and maxillofacial surgeon.⁴⁹ Cellulitis that extends along fascial planes to involve other anatomical spaces requires aggressive treatment due to the potential for morbidity and—rarely—mortality.

Combined periodontal-endodontic lesions

These lesions may be of primary pulpal origin or of periodontal origin.⁵⁰ They may occur in a patient with preexisting periodontitis or in a setting of relatively good periodontal health. If the lesion is primarily endodontic in origin, root canal treatment alone may lead to resolution; however, this can only occur if the lesion is of recent onset.

Clinical characteristics. The clinical presentation includes pain to pressure and percussion, increased tooth mobility, probing depth and attachment loss, and swelling of the marginal gingiva, simulating a periodontal abscess. The suppurative process may cause the formation of a narrow, deep pocket that may be traced to the apex with a gutta-percha cone or a periodontal probe. Pulp testing is negative, or in a multirrooted tooth it may show an abnormal response.⁵¹ All these signs, including radiographic findings, are somewhat variable.

Etiology and pathophysiology. The etiology and pathophysiologic processes are detailed in the preceding sections on periodontal and periradicular abscess.

Management considerations. The periodontal component of the combined lesion may resolve subsequent to root canal therapy, and therefore it is preferable to perform this treatment first and allow for a suitable period of healing. If the periodontal lesion persists, further treatment will be required.⁵² Of note is that vertical root fractures (see following section) may show similar signs and symptoms. Electric pulp testing may help separate these two lesions.

Pulpal and periodontal pain secondary to fractured teeth

Tooth fractures occur in approximately 5% of adults annually.⁵³ In most cases, the fracture of a cusp or a split tooth are readily diagnosed.

Surface cracks, or *craze lines*, are considered incomplete tooth fractures. These incomplete fractures are usually asymptomatic but when painful, they may be due to “cracked tooth syndrome,” which can be difficult to diagnose.²

Clinical characteristics. Patients with a cracked tooth may have complaints of sporadic, sharp, momentary pain on biting or releasing, along with occasional pain from cold stimuli. Sometimes, patients may indicate the pain occurs minutes after chewing.² In contrast with other tooth-related pains, the pain of a cracked tooth is usually easily located.⁵⁴

Etiology. A fracture rarely occurs in teeth that are without caries or have no or small restorations. Predisposing factors include loss of support due to caries or large restorations, inadequate cusp protection by restorations, developmental weaknesses of the tooth, a history of local trauma, and clenching or bruxing habits.^{55–57}

Pathophysiology. The pain associated with a cracked tooth occurs when occlusal forces spread portions of the crown, exposing the underlying dentin. Momentary hydrostatic movement of fluid within the dentinal tubules causes pain.

Differential diagnosis. The diagnosis of a cracked tooth is usually made from history and clinical tests. Generally, percussion, palpation, mobility, and probing are within normal limits if the crack is confined to the crown. The most useful test is biting on successive cusps with a firm object such as a wood stick or Tooth Slooth (Professional Results) until the pain is reproduced. Staining and transillumination may also disclose subtle fractures. In addition, the use of a microscope greatly facilitates the observation of fractures.⁵⁸ Electric pulp testing will produce normal responses unless the pulp is involved. Cold testing may be productive, whereas heat may not be helpful. Frac-

ture lines are not visible on radiographs when they run mesiodistally and are not in the plane of the x-ray beam. If the fracture extends into the root, a periodontal defect may be observed adjacent to the fracture. At this point, the pulp may have become necrotic. Sharp pain and cold sensitivity are not common. Typically, a dull ache on biting might be present when the periodontal ligament is inflamed, resulting in tenderness on percussion.^{14,59}

Management considerations. Early detection of cracked teeth is essential, and therapy depends on the severity of symptoms and location of the crack.^{54,56–59} Temporary stabilization can be achieved with an orthodontic stainless steel band or a provisional crown until an overlay or full crown can be fabricated.⁶⁰ Root canal therapy with or without stabilization has been advocated. In cases with extensive cracks, extraction may be necessary.²

Systemic factors associated with dental infection

Systemic conditions that may modify host response to infection include diabetes, anemia, diseases causing altered neutrophil count and function, immunosuppression (pathologic or medically induced), tobacco use, nutrient and caloric deficiencies, hormone abnormalities, and emotional stress.^{61–64} Additionally, pathologic conditions and/or medications that affect exocrine secretions may influence oral homeostasis through effects on saliva. Rheumatic diseases such as arthritis, Sjögren syndrome, systemic lupus, and systemic sclerosis (scleroderma) are counted among the most common inducers of pathologic changes in salivary glands. Dehydration, alcoholism, and a large variety of medications induce hyposalivation without significant change in glandular tissues. In addition, genetic diseases that affect calcification may interfere in mineralization of teeth. Most common among these are osteogenesis imperfecta and the related dentinogenesis and amelogenesis imperfecta. Patients affected by these conditions are generally more prone to

cariogenic, periodontal, or other oral infectious processes where pain is a prominent feature. Both diagnosis and treatment of these patients involve unusual complexity.

Nonodontogenic Toothache

The clinician should never assume that all patient-reported tooth pain is caused by pulpal or periodontal disease. When the patient reports toothache, the clinician must determine if the pain has its origin in dental structures or if pain is referred from other sites. Effective treatment can only be provided following a correct diagnosis. Because dental pain is so commonly treated in the dental office and nonodontogenic tooth pain is rare, these latter cases are often inappropriately treated with dental therapy before appropriate diagnosis of the cause. The appropriate diagnosis is often made after multiple treatment failures that may include invasive and irreversible procedures such as root canal therapy and tooth extractions.^{65,66}

Potential identifiers of nonodontogenic toothache include:

- Spontaneous multiple-tooth pain
- Inadequate dental cause for the pain
- Stimulating, burning, electric/lancinating pain, nonpulsatile toothaches
- Constant/persistent, unremitting toothaches
- Persistent, recurrent toothaches
- Failure of local anesthesia to significantly reduce pain
- Failure of the toothache to respond to reasonable dental therapy
- Pain referral to region of tooth from muscle trigger points
- Associated autonomic symptoms such as tearing, conjunctival injection, regional sweating, and other vascular phenomena
- Regional pain and paresthesia
- Severe headache

- Recent cold, allergy, stuffiness, and coughing with pain on maxillary teeth

Nonodontogenic toothache may be differentiated from odontogenic toothache by local provocation. Pulpal and periodontal pains are increased by local stimulation such as percussion, hot, cold, or bite forces. When the pain is not increased by provocation, the clinician should be suspicious of a nondental etiology. Local anesthetic may be helpful in differentiating true dental pain from pain referred to the teeth. Local anesthetic placed at the site of the nonodontogenic toothache often will be ineffective because the site of pain report is not the true source.^{67,68} Pain can be referred to the teeth from multiple sources including myofascial trigger points in the masseter (most common muscle source), temporalis, medial pterygoid, lateral pterygoid, and anterior digastric muscles. Maxillary sinusitis or a regional tumor may be a source of maxillary tooth pain.^{69–72} Nonodontogenic toothache may also result from continuous neuropathic pain (ie, deafferentation, neuritis, neuroma, persistent dentoalveolar pain), episodic neuropathic pain disorders (ie, neuralgias), and other neoplastic or neurovascular disorders.⁷³ CNS disease and cardiac pain may also be experienced as toothache.^{74,75} In some instances, psychogenic conditions may also present as tooth pain. Knowing the pain characteristics and referral patterns for each of these sources is essential for differential diagnosis.

Oral Mucosal Pain

Local mucogingival and glossal pains

Localized mucosal pain is often associated with a detectable lesion resulting from physical, chemical, or thermal trauma; infection; inflammation; neoplasia; immune dysfunction; or other origin. The pain experienced is typically localized to the site of mucosal change.

A response to stimulation (eg, eating spicy or acidic foods or contact with toothpaste) is representative in intensity and location, and topical anesthetic at the site modulates the pain. By contrast, for diffuse mucosal pain, it may be difficult to identify the specific cause unless widespread lesions are obvious. This type of pain may result from a direct insult to the tissues due to local or CNS lesions that require special studies or bacterial, viral, or fungal infection, which can be identified by the characteristic appearance of the oral mucosa and confirmed with diagnostic testing. Diffuse pain may also be due to radiation therapy and cytotoxic or targeted chemotherapy, which may result in acute mucositis with severe generalized pain that may persist past healing of the lesions as chronic mucosal pain. Burning sensation of the oral mucosa, particularly the tongue, may result from neuropathy/neuralgia, hyposalivation, use of certain medications, and in some cases, nutrient deficiency diseases. Generalized diffuse pain with a symmetric distribution in the oral mucosa, with a burning quality that may be accompanied by a change in taste, may represent burning mouth syndrome (see chapter 6).³⁹

Necrotizing disease

Necrotizing mucosal conditions are generally characterized by severe pain, and they often hemorrhage on slight provocation. The term *necrotizing periodontal diseases* includes the somewhat arbitrary terms *necrotizing ulcerative gingivitis* (NUG) and *necrotizing ulcerative periodontitis* (NUP), which have been used to distinguish necrotizing conditions that present with or without attachment loss.⁷⁶ Tissue necrosis of gingiva or periodontium may run a short course or may become chronic; therefore, the term *acute* has been deleted.

Spontaneous or, more commonly, trauma- and/or extraction-associated soft tissue and jaw bone necrosis has been described in association with antiresorptive bone medications or osteolytic inhibitors such as bisphosphonates

and receptor activator of nuclear factor κ B ligand inhibitors (eg, denosumab) and antivascular drugs. Cases related to other biologic therapies have also been reported.⁷⁷ *Antiresorptive agent-related bone necrosis* is defined as a history of bone exposure in the mandible or maxilla of more than 8 weeks' duration, though this concept has been challenged.⁷⁸

Clinical characteristics. NUG/NUP is characterized by painful, hyperemic, fiery red gingiva and punched-out ulceration of the interdental papilla. The lesions bleed easily and are often covered with a gray necrotic pseudomembrane. The patient may complain of bad breath and inability to eat. Occasionally, systemic symptoms are seen, such as malaise and low-grade fever. The lesions may occasionally involve other areas of the oral mucosa (necrotizing ulcerative stomatitis), which is usually seen in debilitated or immunocompromised individuals (also known as noma, gangrenous stomatitis, and cancrum oris).⁷⁹⁻⁸¹ When the condition occurs in immunocompetent individuals, which is usually the case, the patient is often a young adult with poor hygiene who is also a heavy frequent smoker. Patients who do not fit this profile should be evaluated for potential predisposing immunosuppressive conditions including blood dyscrasia and HIV/AIDS.

Etiology. Vascular changes associated with emotional stress, tobacco use, poor oral hygiene, local trauma, fatigue, and impaired host defense predispose the individual to infection and tissue necrosis.⁷⁹

Pathophysiology. NUG was originally referred to as a fusospirochetal disease. More recently, *P intermedia* has been implicated, along with various *Treponema spp*, *Fusobacterium spp*, and *Selenomonas spp*.⁸²

Management considerations. Treatment of NUG/NUP consists of mechanical debridement; systemic antibiotic therapy with met-

ronidazole, tetracycline, or doxycycline; and 0.12% chlorhexidine mouthrinse.

Aphthous stomatitis (ICD-10 K12.0)

Aphthous stomatitis is the most common oral mucosal disease affecting the general population. Aphthae may present in three clinical forms: minor, major, and herpetiform. Aphthous minor is the most widespread form with a prevalence of 17.7% of the general population (80% of the cases of aphthous stomatitis). The prevalence of the major form ranges from 10% to 15%.⁸³ Herpetiform cases comprise 7% to 10%.^{84–88}

Clinical characteristics. Aphthous minor appears as discrete, painful, shallow, recurrent ulcers, covered by a yellowish-gray pseudomembrane, that are surrounded by an erythematous halo. Ulcers typically number one to five at any one time and measure less than 10 mm in diameter. These lesions are painful and usually heal within 10 to 14 days without scar formation.⁸⁹ Aphthous major produces ulcers that are usually larger than 10 mm in diameter, may persist for weeks, and may be recurrent or present continuously for extended periods. They appear as very painful, large, deep-based ulcers containing a yellow-gray necrotic center, and they may develop raised, rolled borders with a predilection for the lips, soft palate, posterior aspect of the tongue, and tonsillar fauces. These lesions may heal with scarring. Herpetiform aphthae occur in crops of 10 to 100 at a time, usually in the posterior part of the mouth.⁸⁹ The ulcers measure 1 to 3 mm in diameter but sometimes coalesce, creating a look reminiscent of a herpetic infection. In all types of aphthae, ulcers predominantly involve nonkeratinized mucosa of the mouth: the labial and buccal mucosae, maxillary and mandibular sulci, nonattached gingiva, floor of the mouth, ventral surface of the tongue, soft palate, and tonsillar fauces. Ulcers of this type typically spare the keratinized mucosa of the dorsum of the tongue, the attached gingiva, and the

hard palate. While patients may develop sub-mandibular lymphadenopathy, fever is rare.⁹⁰

Etiology. Factors that play a role in triggering the development of aphthous stomatitis include hormonal changes, trauma, stress, and food allergies. Foods associated with aphthous stomatitis include bovine milk protein, gluten, chocolate, nuts, cinnamon, spices, and preservatives.^{90,91} A number of medications are known to cause aphthous-like lesions, including nonsteroidal anti-inflammatory drugs (NSAIDs) and “targeted” cancer therapies (eg, mammalian target of rapamycin [mTOR] inhibitors).⁹² Deficiencies of ferritin and vitamin B₁₂ have also been associated with this condition.⁹³ Nevertheless, the complete etiology remains unknown.

Pathophysiology. Causative microorganisms have not been identified. Rather, the disease is considered to result from immune dysfunction with overexpression of tumor necrosis factor α (TNF α). Blood studies from otherwise healthy persons with aphthous stomatitis have found various immune abnormalities: depressed or reversed CD4:CD8 cell ratios (especially in persons with severe stomatitis), increased T-cell receptor d+ cells in patients with active aphthae compared with controls, and patients with inactive aphthous stomatitis.^{88,94,95}

Management considerations. Therapeutic agents such as topical steroids, topical tetracyclines, and amlexanox 5% oral paste have been effective in decreasing the symptoms and healing time, but nothing has been effective in decreasing the recurrence rate unless a trigger or a serum deficiency can be identified.^{96–100} Other treatments for minor aphthae include topical anesthetics, mouthrinses, caustic agents, and laser ablation. In cases of major aphthous stomatitis where the healing process may be prolonged and topical corticosteroids have not been effective, therapy may include systemic and/or intralesional steroids

or thalidomide. Other drugs that have been advocated are lysine, dapsone, azathioprine, and etanercept. Interventions with anti-TNF effects may have a future role.^{101,102}

Infections

Viral infection

Herpes family viruses often cause oral mucosal and salivary gland infection in either primary or reactivated form.¹⁰³ The most common pathogens affecting the oral mucosa are the herpes simplex virus (HSV) members (HSV 1 and 2, primarily the former), but recent research identified a relatively high prevalence of human herpes virus (HHV) 6, 7, and 8 in the oral mucosa. The varicella zoster virus (VZV) is present in all patients with a history of chicken pox, whereas cytomegalovirus (CMV) or Epstein-Barr virus (EBV) may be latent in those patients with a history of mononucleosis. Common to all herpes viruses is the fact that after primary exposure (which may or may not produce overt disease), the virus achieves a dormant state and is subject to episodic reactivation.

Primary herpetic gingivostomatitis. Primary herpetic gingivostomatitis occurs in individuals without prior exposure to the virus. These infections are seen mostly in children and young adults. When symptomatic, the clinical manifestations include diffuse oral lesions and possible systemic involvement. The initial presentation has rapid onset of generalized prodromal signs and symptoms, including erythema, pruritus, fever, malaise, headache, irritability, and regional lymphadenopathy, followed by the development of frank oral lesions that consist of severe generalized inflammation and vesicles primarily involving keratinized mucosa of the lips, gingiva, tongue, and palate. The vesicles rupture rapidly, forming shallow, ragged, painful ulcerations with a yellowish center and erythematous borders. The lesions begin as clustered, punctate (1- to 2-mm rounded) ul-

cerations that may coalesce to form irregular lesions that usually heal within 2 weeks. In some cases, extraoral ulcerations develop on the skin and vermillion borders of the lips, with resultant crusting and oozing. Severe pain, foul odor, and increased salivation may accompany the oral lesions. Diagnosis is most often based on the history and clinical presentation. Laboratory diagnosis is not usually necessary except in the setting of immunosuppression or atypical presentation.¹⁰⁴ Diagnosis can be confirmed by direct viral culture, fluorescence or peroxidase stain, or by assessing acute and convalescent viral serology.

Secondary (recurrent) herpetic gingivostomatitis. The prevalence of secondary or recurrent HSV has been estimated at 20% to 40% of the population worldwide and 35% to 38% in the United States.¹⁰⁵ Recurrent infections are caused by reactivation of the virus, which is latent in the trigeminal ganglion.

Clinical characteristics. Recurrent herpes infection is characterized by mostly unilateral vesicular eruptions surrounded by erythema, followed by crusting and healing. The eruptions are often preceded by a prodromal tingling sensation. Oral mucosal lesions are rare and usually restricted to small clusters of vesicles (1 to 3 mm in size) that rupture, resulting in punctate ulcers, typically on the palatal gingiva (occasionally elsewhere on the gingiva) unilaterally. The lesions may be triggered by ultraviolet light exposure, stress, immunosuppression, or dental procedures. The lesions are usually self-limiting, resolving within several days.¹⁰⁶ Extraoral lesions may appear on the skin, genitalia, anal and perianal areas, eyes (keratitis, keratoconjunctivitis), and nervous system (encephalitis, meningitis).^{107,108}

Etiology. The typical route of HSV transmission is physical contact with an infected individual by someone who has not been previously exposed to the virus. During the primary

infection, only about 50% of individuals show clinical signs and symptoms, while most experience a subclinical course. This latter group becomes seropositive and can be identified through laboratory evaluation of circulating antibodies to HSV.¹⁰⁹ Approximately 90% of adults are seropositive for HSV 1 and about 35% for HSV 2, which are the most common agents for mucosal lesions.

Pathophysiology. The incubation period for primary infection ranges from several days to 2 weeks after exposure to the virus. The clinical picture consists of a vesiculo-ulcerative eruption on the mucosal tissues at the site of inoculation. Following resolution of primary herpetic gingivostomatitis, the virus becomes latent in the trigeminal ganglia. Reactivation of the virus is not fully understood but may follow exposure to ultraviolet light, trauma and stress, or immunosuppression, causing a secondary or recurrent infection. Virions assemble and migrate along the nerve and enter epidermal cells, causing vesicles that ulcerate at the epithelial surface. Because the humoral and cell-mediated arms of the immune system have been sensitized to HSV antigens, the lesions typically remain localized, and systemic symptoms are rare. As the secondary lesion resolves, the virus returns to its latent state.¹⁰⁹ It is worth noting that viral shedding occurs commonly in infected individuals, from oral and genital sites, without clinical symptoms or overt lesions. Hence, contagion can occur even in the absence of clinical lesions. In immunosuppressed patients, recurrent lesions may spread, persist for longer periods, and present atypical appearances including ulceration of attached and unattached mucosa in contrast to those of nonimmunosuppressed patients.

Varicella zoster infection. Primary infection with VZV (chicken pox) is also a disease with recurrent episodes (shingles or herpes zoster). It is estimated that in the United States, more

than 90% of adults are susceptible to VZV reactivation.¹¹⁰ With an estimated 30% chance of reactivation over the lifetime, about one million cases of shingles occur in the United States annually. Common causes of reactivation include age over 60 years, immunosuppression, or trauma. Reactivation of VZV has a typical onset with pain that can be severe, followed by segmental distribution of lesions that may involve the head, neck, and oral cavity. Herpes zoster may run its course, and the virus becomes latent in immunocompetent patients but may spread locoregionally or cause systemic infection in immunosuppressed individuals. Postherpetic neuralgia is quite common after shingles and may result in persisting chronic neuropathic pain following resolution of active infection. Other herpes viruses may occasionally cause oral lesions, including CMV and HHV 8, which are responsible for ulcerations in immunocompromised patients, and Kaposi sarcoma. Acute infection by CMV and the EBV may cause mononucleosis-like symptoms. CMV may become latent in salivary gland tissue and has been associated with cancer at that location. EBV is associated with nasopharyngeal cancer, B-cell lymphoma, and posttransplant lymphoproliferative disorder. HHV 6 (A and B) and 7 are commonly found in the salivary glands and tonsils and contribute to the reactivation of CMV and EBV.

Management considerations. Treatment of primary herpetic gingivostomatitis focuses on supportive care to prevent dehydration by ensuring adequate fluid intake and oral nutrition. Systemic analgesics may be required for pain management. Systemic antiviral agents such as acyclovir and valacyclovir may be indicated and are mandatory in immunocompromised patients or those with ocular involvement.¹¹⁰ Treatment of recurrent herpetic gingivostomatitis is early prescription of acyclovir or one of its congeners (eg, famciclovir, valacyclovir).¹¹¹ A recent systematic review on the safety of nucleoside antiviral drugs for the treatment

of recurrent herpes labialis, including 25 randomized controlled trials, found that systemic administration was more effective than topical administration. In addition, it was found that valacyclovir was more effective than acyclovir. The study also found that famciclovir and penciclovir did not prevent the development of lesions, although the use of penciclovir reduced time to heal as effectively as valacyclovir and acyclovir.¹¹² Lysine supplements have not been subjected to rigorous trials.¹⁰² Active herpetic lesions should be considered infectious until complete reepithelialization. Patients should be warned of the possibility of transmission to others, especially infants and the immunocompromised.¹¹¹ Autoinoculation of the virus into other receptive mucosal sites (eg, the eye) is also possible. For dental professionals, herpetic whitlow and herpetic conjunctivitis is a professional risk. Management of herpes zoster includes use of antivirals (eg, acyclovir 800 mg three times daily) early after reactivation and consideration for systemic corticosteroid use to prevent possible progression to postherpetic neuralgia. There is a vaccine (Zostavax, Merck) that is currently approved for the prevention of herpes zoster (51% effective) and postherpetic neuralgia (66% effective). Additionally, vaccination has been shown to reduce the incidence of postherpetic neuralgia by 39% among patients who develop herpes zoster. The Centers for Disease Control and Prevention recommend that patients aged 60 years and older be vaccinated regardless of their prior exposure to VZV. However, the vaccine is approved for patients as young as 50 years of age.^{113,114}

Candidiasis (ICD-10 B37.0)

Candidiasis encompasses a group of mucosal and cutaneous conditions most commonly caused by the yeast *Candida albicans*. Other members of the *Candida* genus such as *C. tropicalis*, *C. krusei*, *C. parapsilosis*, *C. guilliermondii*, and *C. dubliniensis* are rarely the cause of disease; however, continuing overuse of

antifungals has led to an increase in the prevalence of strains that are resistant to common drugs, particularly in immunosuppressed individuals.^{115,116} *Candida* species are opportunistic pathogens that may lead to clinical overgrowth and frank, local, and—rarely—systemic infection due to changes in oral conditions, oral flora, and systemic status of the host.¹¹⁷

Pseudomembranous candidiasis. The pseudomembranous form occurs most commonly in infants, elderly patients, or those with white cell or immune deficiencies. The lesions present as superficial, curd-like white plaques that wipe off, leaving an erythematous, eroded, or ulcerated surface. Plaques are composed of fungal organisms, keratotic debris, inflammatory cells, desquamated epithelial cells, bacteria, and fibrin. The lesions commonly affect the palate, buccal mucosa and mucobuccal folds, lateral and dorsal aspects of the tongue, and oropharynx. Patients may have no symptoms or may complain of tenderness, mucosal burning, taste change, and odynophagia. Predisposing factors include a history of medication with broad-spectrum antibiotics or corticosteroids, hyposalivation, wearing of removable dentures, tobacco use, nutritional deficiency, diabetes, malignancy, chemotherapy, radiation therapy, and cell-mediated immune dysfunction, including that induced by HIV.

Erythematous (atrophic) candidiasis. Erythematous lesions are most often seen on the middorsal tongue (median rhomboid glossitis) and on denture-bearing areas of the palate. Oral tenderness, burning, taste change, and odynophagia are common. Predisposing factors are the same as those listed above. Erythematous candidiasis may also occur under dentures, presenting with erythema and edema on a velvety or pebbly surface (ie, papillary hyperplasia). Chronic candida infections are also capable of producing a hyperplastic tissue response with inter- and intracellular invasion of the epithelium. White lesions may

include palpable thickness and irregular surface texture with or without erythema. These lesions are mostly asymptomatic. Predisposing factors include inherited or acquired altered cellular immunity and general local risk factors for candidiasis. Angular cheilitis presents as localized erythema and/or ulcerations, uni- or bilaterally at the commissures of the lips. The lesions may be painful, eroded, and crusted when extending onto the skin surface. Angular cheilitis is often associated with intraoral forms of candidiasis. Predisposing factors include overclosure of the jaw, drooling at the corners of the mouth, lip-licking and/or thumb- or digit-sucking habits, and risk factors common to all other forms of candidiasis. Angular cheilitis is often a mixed infection of *Candida* and salivary species of streptococci and staphylococci. The diagnosis of candidiasis may be made from the patient history and the clinical appearance and distribution of the mucosal lesions. When necessary, especially in an immunocompromised individual, identification of the organism is made in a culture or smear from the lesion. For hyperplastic lesions, biopsy followed by microscopy with fungal stain is necessary.¹¹⁸

Management considerations. The underlying risk factors for candidiasis should be identified and managed when possible, or recolonization and recurrence of infection is likely, as the yeast can rarely be completely eliminated. Oral candidiasis is most often treated with antifungal agents such as topical polyenes (nystatin) and azoles (clotrimazole, miconazole). Oral preparations in the form of troches or adherent patches provide the advantage of prolonged contact of the medication with the lesions.¹⁰¹ The angular cheilitis lesions respond well to broad-spectrum antimicrobials or combination therapy containing an antifungal and a topical steroid (miconazole with betamethasone dipropionate or nystatin with triamcinolone acetonide). Persistent lesions may require addition of antibacterial creams, such as mupirocin (Bactroban, GlaxoSmithKline),

and treatment of oral infection/colonization. Recurrence is common if the underlying risk factors are not managed. In cases of refractory candidiasis in immunosuppressed patients and for chronic mucocutaneous candidiasis, a systemic antifungal from the azole family such as fluconazole is a common choice. For persisting cases, next-generation antifungals are available.

Mucosal trauma

Trauma is a common cause of irritation and ulceration of the oral mucosa. Traumatic oral lesions may be accidental, factitial, or iatrogenic and may result from physical, chemical, or thermal insults to the tissue.¹¹⁹ Hyposalivation may predispose a patient to traumatic lesions of the mucosa. Chemical and thermal burns are rare because the oral mucosa is quite resistant to heat and acid or alkaline compounds. Thermal burns usually affect the hard palate and are most commonly caused by ingestion of hot liquids or hot melted cheese (pizza-palate). Electrical burns are almost exclusively seen in children who may bite electric cords. Mucositis due to cancer therapies, including radiation and/or chemotherapy for head and neck cancer or other solid tumors, and hematopoietic malignancies, are common significant and treatment-limiting complications (see below). Chemical burns can be a consequence of deliberate or accidental ingestion of caustic agents; prolonged contact with aspirin or vitamin C tablets; use of undiluted oral antiseptics; contamination of prosthesis with denture cleaners; or accidental contact with phosphoric, chromic, or trichloroacetic acid during dental treatment. As the offending cause or agent is usually quickly discontinued or deleted, most traumatic injuries to the oral mucous membranes will be acute in nature. Management includes identification of the cause, discontinuing the offending agent, management of risk factors (eg, hyposalivation), and symptomatic care.¹¹⁹

Cancer pain

Approximately 3% of all malignancies in the United States are oral and oropharyngeal, with 90% of these being oral squamous cell carcinomas (OSCCs). Annually in the United States, there are nearly 45,000 new cases and more than 9,000 deaths due to head and neck cancers. Improved survival rates have been reported in the recent past, reflecting change in cancer etiology involving human papilloma virus and changes in cancer therapy. Unfortunately, the improvement does not appear related to early detection, as approximately two-thirds of OSCC are diagnosed in advanced stages.^{120,121} Discomfort is common at diagnosis, and management remains difficult because the neural mechanisms underlying cancer pain are poorly understood and because of lack of adequate pharmacologic management options.¹²² Oral involvement by hematologic cancers and orofacial spread of metastatic cancer frequently cause oral pain. Pain from cancer may be due to the malignant disease itself or to anticancer therapy. Pain from OSCC may be due to ulceration; pressure on nerves; invasion of nerves, vessels, muscle, and periosteum; or secondary infection. When intraoral neoplasms become large, patients may complain of paresthesia or hypoesthesia that may be accompanied by loose teeth; mass or swelling; and/or restriction of tongue, lip, or jaw movement.¹²³ Also, as with other painful conditions involving the orofacial structures, pain from cancer may be felt at the primary site, may be referred to another site, or both.

Symptoms from metastatic lesions to the jaw may be the first indication of a distant tumor or may occur during the course of the disease, most commonly breast, prostate, colon, or lung, frequently causing unilateral pain, paresthesia, or anesthesia. Hematologic cancers may involve gingival tissues directly and may be associated with intraoral infection (eg, pericoronitis). Lymphoma commonly involves lymphatic tissues of the head and neck

and can present with cervical adenopathy and/or infiltration of gingival tissues with or without discomfort. Solitary tumors may appear on the palate. Cancers may also produce inflammatory cytokines and release nociceptive and sensitizing molecules that stimulate nerve pain, such as bradykinin, 5-HT, substance P, and endothelin-1.

Pain due to cancer treatment

Head and neck cancer treatment may include surgery, radiation therapy, chemotherapy, targeted agents, and immunotherapy. Treatment-induced acute pain occurs due to surgery or due to mucositis induced by radiation or chemotherapy. The most distressing side effect of head and neck cancer therapy is pain due to mucositis. In radiation therapy, mucositis develops following release of reactive oxygen species, proinflammatory cytokines, and sensitizing and nociceptive molecules (eg, bradykinin, 5-HT, prostaglandins, substance P). When ulcerative mucositis is present, the condition is aggravated by secondary microbial irritation, resulting in further upregulation of proinflammatory cytokines and nociceptive molecules. In cycled chemotherapy, mucositis and associated pain may occur in up to 25% of patients; it is more common in patients with mucositis in prior courses of chemotherapy and is more common in later cycles. In hematopoietic stem cell transplant (SCT), symptomatic mucositis occurs in more than half of the patients, and as in radiation therapy, it may be the most significant acute symptom these patients experience. Current mucositis management frequently requires use of opiate/opioid analgesics and possible adjuvant medications. In radiation therapy, mucositis may persist for a few weeks following completion of therapy; with chemotherapy alone, mucositis may persist for 1 to 2 weeks; and in combined chemotherapy and radiation therapy, it may continue for 1 to 2 months or even longer periods. Severe ulcerative mucositis may also be associated with chronic mucosal sensitivity that has

been reported to persist for months to years, and possibly indefinitely in many patients following cancer therapy.

Other mucosal pain-inducing mechanisms may be at work in patients undergoing cancer therapy. In immunosuppressed and myelosuppressed patients, herpes viruses are common causes of mucosal lesions and pain. Following SCT, oral graft versus host disease (GVHD) may be a cause of symptomatic mucosal lesions (see immune-mediated mucosal lesions). Lastly, many cytotoxic agents (eg, platinum and taxane agents) may affect nerve cells, producing neurogenic pain that can manifest in the orofacial region (see below). All of these mechanisms can induce mucosal pain and taste change that can affect oral function, nutrient and energy intake, and quality of life. Post-cancer treatment muscle fibrosis can occur with surgical intervention and radiation therapy and may be increased in patients with chemotherapy. Head and neck cancer patients may have fibrosis, limiting movement of the tongue and lips and limiting jaw movement. Neuropathy following head and neck cancer treatment and radiation therapy– and/or chemotherapy-induced neuropathy is common and may result in orofacial pain.

Management of cancer-related oral pain is dependent on its cause: tumor-induced symptoms will regress with anticancer treatment, while therapy-induced mucositis requires topical and/or systemic analgesics because no effective therapy has been described. Several prevention methods of cancer therapy–induced mucositis have been described, including cryotherapy (cooling of the mouth during infusion of cytotoxic agents), the drug Kevivance (Biovitrum; keratinocyte growth factor 2), and low-level laser therapy. Oral pain of infectious etiology requires the use of the appropriate antimicrobial agent.

Geographic tongue (benign migratory glossitis, erythema migrans) (ICD-10 K14.1)

Clinical characteristics. Geographic tongue is a benign inflammatory disorder that is characterized by multiple, well-demarcated zones of erythema located on the dorsum and lateral borders of the tongue. Lesions may be present in the buccal mucosa and lip (stomatitis areata migrans) and rarely other oral surfaces.^{124–126} The condition is not usually symptomatic but may occasionally present with a burning sensation, often related to the consumption of food (particularly spicy, hot food, or foods and drinks high in acid content), likely related to tissue inflammation. Fissured tongue is frequently observed. Lesions vary in size and shape and may have episodic occurrence.¹⁰⁹

Etiology. The etiology of geographic tongue remains unclear. The lesion has not been linked to stress and/or infection. It has been suggested that it may represent a manifestation of psoriasis.^{109,124}

Pathophysiology. Loss of adhesion molecules may underlie the clinical findings of red areas (atrophic tongue) surrounded by a white border of less attached epithelium.

Management considerations. Reassurance and education is generally the only treatment indicated. When symptomatic, topical steroids and/or analgesics may be helpful.^{125,126}

Immune-mediated inflammatory conditions

Painful oral conditions may occur due to drug-induced reactions or subsequent to hyposalivation induced by many medications,

including tricyclic antidepressants, antipsychotics, muscle relaxants, antihistamines, anticonvulsants, diuretics, anxiolytics, opioid analgesics, and antihypertensive agents. A number of inflammatory/immune disorders may present only in the oral cavity or associated with clinical extraoral manifestations, including lichen planus, aphthous stomatitis, erythema multiforme, mucous membrane (cicatricial or bullous) pemphigoid, pemphigus vulgaris, and lupus erythematosus. Pain is common with these lesions. Oral lichen planus is the most common immune-mediated condition and can cause pain due to inflammation, including neurogenic inflammation/sensitization and mucosal ulceration. Pain is commonly aggravated by spicy, acidic, and highly flavored foods or oral care products. A number of other systemic diseases are known to present with erythematous, erosive, ulcerative or hemorrhagic, and generally painful lesions in the oral cavity. These include discoid and systemic lupus erythematosus, uncontrolled diabetes mellitus, uremia, Crohn disease, and blood dyscrasias, such as leukemia and pancytopenia, agranulocytosis, cyclic neutropenia, and sickle cell anemia. GVHD is an inflammatory condition that may follow allogeneic bone marrow (hematopoietic) SCT that may affect oral tissues, resulting in lichenoid or lupus-like lesions.

Clinical signs and symptoms are rarely pathognomonic, so diagnosis of systemic and/or immune-mediated oral lesions requires laboratory testing, including specific blood components and biopsy specimen immunofluorescence studies. Therefore, these lesions should be referred to specialists or hospital practices for appropriate evaluation. Management of diagnosed immune-mediated lesions requires therapy that involves local and/or systemic immune modulation, with initial treatment often consisting of corticosteroids. Pain relief is typically rapid after inception of appropriate therapy and can be further managed with topi-

cal anesthetics or systemic analgesics. Lack of response to immunoactive drugs should increase suspicion of primary or secondary infection of the lesions. Complete remission of the disease is a rare outcome, and these conditions generally require chronic treatment and frequent follow-ups.

Mucosal pain secondary to HIV

The number of oral lesions in HIV-infected individuals has decreased considerably since the introduction of effective antiretroviral therapy. Nevertheless, painful lesions persist in this population and are directly related to immune incompetence.¹²⁷ Orofacial pain may be due either directly to HIV infection or to comorbid conditions, including mucosal infection and necrotizing diseases.¹²⁸ Causes of oral pain in this population may include herpetic gingivostomatitis, recurrent zoster, candidiasis, progressive gingival and periodontal disease, necrotizing gingivitis or periodontitis, or Kaposi sarcoma or other malignant disease (eg, OSCC, lymphoma), among others. Pain may also be due to HIV-associated peripheral neuropathy. As with all patients, a proper diagnostic evaluation and identification of disease processes must precede treatment (other than palliation). Painful oral ulcerative conditions are often seen and may be caused by a variety of pathogens, including fungi, viruses, parasites, and bacteria, or they could represent aphthous lesions or tumor.^{129–135} Nonulcerative lesions can occur with nonspecific mucositis, hyposalivation, and nutritional deficiencies.²⁷ The treatment of oral pain in the patient with HIV/AIDS will depend on the specific diagnosis. Symptom management employing analgesics including NSAIDs or acetaminophen to control mild to moderate pain is generally indicated. If the pain is not adequately controlled, an opioid may be prescribed. Various chemotherapeutic or analgesic mouthrinses or topical agents may also be useful in some cases.

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Differential Diagnosis and Management of TMDs

8

Key Points

- ◇ Temporomandibular disorders (TMDs) rarely result in disabling conditions.
- ◇ There is no single cause for all TMDs. Benign TMD signs and symptoms are very common among the general population and are generally self-limiting.
- ◇ Only 3.6% to 7% of the general population has TMDs severe enough that they seek treatment. Patients with pain-free TMJ clicking generally do not need treatment; reassurance and education about this benign condition usually suffices.
- ◇ Management of TMDs should include the control of contributing factors such as parafunctional oral habits.
- ◇ Smoking habits and certain disorders may influence TMD symptoms and prognosis, so these factors should be addressed.
- ◇ Management of TMDs may include self-management instructions, oral appliances, pharmacotherapy, and physical therapy.
- ◇ Generally, invasive surgical management is indicated only after reasonable nonsurgical efforts have failed and when the patient's quality of life is significantly affected.
- ◇ Radiographic structural changes consistent with degenerative joint disease (DJD) should not be used as the sole guide for treatment decisions.

Anatomy of the Masticatory Structures

Temporomandibular articulation occurs in the temporomandibular joints (TMJs), two of the most complex joints of the body. The TMJ is technically considered a ginglymoarthrodial joint because each TMJ provides for both hinging or rotation movement in one plane (a criterion for a ginglymoid joint) and for gliding or translation movements (a criterion for an arthrodial joint).¹ The TMJ is formed by the mandibular condyle fitting into the mandibular (glenoid) fossa of the temporal bone (Fig 8-1).¹ Separating these two bones from direct contact is the interposed articular disc (sometimes inappropriately called a *meniscus*). The articular portion of the healthy disc is composed of dense fibrous connective tissue, devoid of any nerves or vessels; conversely, the posterior attachment of the disc is richly vascularized and innervated.²⁻⁴ Collateral ligaments attach the disc to the condyle both medially and laterally. These ligaments permit rotational movement of the disc on the condyle during opening and closing of the mouth.

This so-called condyle-disc complex translates out of the fossa during extended mouth opening (Fig 8-2).¹ Therefore, in the normal joint, rotational movement occurs between the condyle and the inferior surface of the disc during early opening (the inferior joint space), and translation takes place in the space between the superior surface of the disc and the fossa (the superior joint space) during later opening. Movement of the joint is lubricated by synovial fluid, which also acts as a medium for transporting nutrients and waste products to and from the articular surfaces. Unlike most synovial joints, the articulating surfaces of the TMJs are lined with dense fibrocartilage instead of hyaline cartilage.⁵ This is an important feature because fibrocartilage has a greater ability to repair itself than hyaline cartilage. This implies that the management of arthritic conditions of

the TMJ may be different from that of other synovial joints.⁶

Movement of the TMJs is achieved by a group of skeletal muscles called the *muscles of mastication*. These muscles are comparable to other skeletal muscles in physiology and ergonomics.⁷ Although the muscles of mastication are the primary muscles that provide mandibular movement, other associated muscles of the head and neck furnish secondary support during mastication. The masticatory muscles include the masseter, medial pterygoid, and temporalis muscles, which predominantly elevate the mandible (mouth closing); the digastric muscles, which assist in mandibular depression (mouth opening); the inferior lateral pterygoid muscles, which assist in protruding and lateral movements of the mandible; and the superior lateral pterygoid muscles, which provide stabilization for the condyle and disc during function.⁸⁻¹¹ The masticatory muscles perform a variety of functional behaviors that include talking, chewing, and swallowing.¹² A number of muscle behaviors are nonfunctional (ie, parafunctional), defined under the broad term of *bruxism*, and include grinding, clenching, or rhythmic chewing-like, empty-mouth movements.^{13,14}

Defining TMDs

TMDs encompass a group of musculoskeletal and neuromuscular conditions that involve the TMJs, the masticatory muscles, and all associated tissues, and they have been identified as a major cause of nondental pain in the orofacial region.^{15,16} TMDs represent clusters of related disorders in the masticatory system with many common symptoms. The most frequent presenting symptom is pain, usually localized in the muscles of mastication or the preauricular area. Chewing or other mandibular activities usually aggravate the pain. In addition to complaints of pain, patients with these disorders frequently have limited mandibular movements and TMJ sounds that are most fre-

Fig 8-1 Normal anatomy of the TMJ. ACL, anterior capsular ligament (collagenous); AS, articular surface; IRL, inferior retrodiscal lamina (collagenous); RT, retrodiscal tissues; SC and IC, superior and inferior joint cavities; SLP and ILP, superior and inferior lateral pterygoid muscles; SRL, superior retrodiscal lamina (elastic). (Reproduced with permission from Okeson.¹)

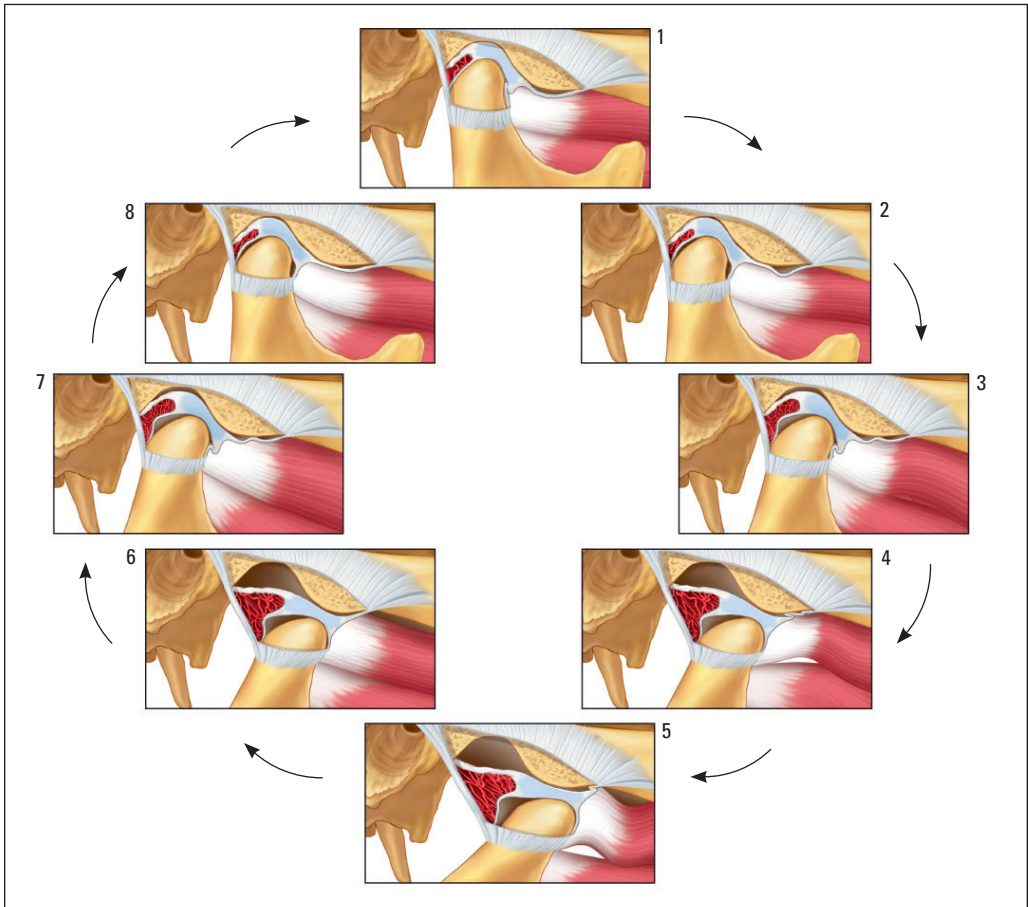
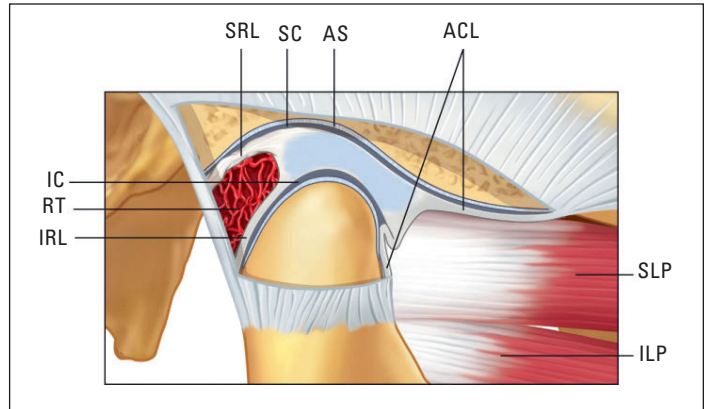


Fig 8-2 Normal functional movement of the condyle and disc during the full range of opening and closing. Note that the disc is rotated posteriorly on the condyle as the condyle is translated out of the fossa. The closing movement is the exact opposite of opening. (Reproduced with permission from Okeson.¹)

quently described as clicking, popping, grating, or crepitus.

Common patient complaints include jaw ache, earache, headache, and facial pain. Non-painful masticatory muscle hypertrophy and abnormal occlusal wear associated with oral parafunction such as bruxism (eg, clenching and grinding) may be related problems. Pain or dysfunction due to nonmusculoskeletal causes such as otolaryngologic, neurologic, vascular, neoplastic, or infectious disease in the orofacial region is not considered a primary TMD even though secondary musculoskeletal pain may be present.

Epidemiology of TMDs

Reports on prevalence of TMDs from cross-sectional epidemiologic studies vary considerably from study to study because of differences in terminology, operational definitions, data collection, analytic approaches (eg, single-factor versus multiple-factor analysis) and bias. A systematic review including only studies adopting the Research Diagnostic Criteria for TMDs (RDC/TMD) reported a prevalence of up to 13% for masticatory muscle pain, up to 16% for disc derangement disorders, and up to 9% for TMJ pain disorders in the general population.^{17,18} While the prevalence of the different diagnoses in TMDs within patient populations varied widely, the results of a meta-analysis showed a prevalence of 45%, 41%, and 30% for muscle disorders, disc derangement disorders, and joint pain disorders, respectively.¹⁸ Data from the National Health Interview Survey from 2009 show that 5% of the US adult population (11.5 million people) self-reported jaw or face pain in the preceding 3 months.¹⁹ Other studies show that TMDs are primarily a condition of young and middle-aged adults, rather than of children or the elderly, and are approximately twice more common in women than in men.¹⁹⁻²¹ According to a population-based survey, the report of symptoms are 50% more

prevalent in African-Americans, and longitudinal data show that the rate of TMD symptoms was higher and the rate of TMD diagnosis was 52% higher in this population, although the persistency of the symptoms is higher in whites.²² In addition, TMDs are often remitting, self-limiting, or fluctuating over time; the progression to a potentially more serious non-reducing disc status or chronic and disabling intracapsular TMJ disease is relatively uncommon.²³⁻²⁷ In fact, recent data demonstrated that 76% and 71% of soft and hard tissue diagnoses, respectively, remained stable after an 8-year follow up.^{24,27,28}

Only 3.6% to 7% of individuals with TMDs are estimated to require treatment, and the annual incidence rate is estimated to be 2%.²⁹⁻³⁴ For painful TMDs specifically, the most recent estimate for first onset was 3.9%, with 50% of the cases maintaining the condition after 6 months.^{22,30,35,36} Because joint sounds are common, often pain free, and not progressive, it is important to avoid overtreatment of benign chronic reducing and nonreducing disc displacement in the absence of pain and impaired function.²⁷ According to magnetic resonance imaging (MRI) studies, it is estimated that up to 35% of asymptomatic individuals appear to have disc displacements.³⁷

Painful TMD conditions such as myofascial pain and arthralgia have been associated with facial trauma, third molar removal, clenching, physical symptoms (somatization), and female sex.³⁸ Cigarette smoking has been associated with increased risk of TMDs in young adults, and higher levels of pain, psychosocial distress, and sleep disturbances are reported in TMD patients.^{39,40} The relationship between painful TMDs and comorbid conditions has been evaluated by several investigators. Myofascial pain patients self-report more severe headaches, fainting and dizzy spells, gastric acid reflux, fibromyalgia, anxiety, depression psychiatric treatments, phobias, and frequent sore throats compared with arthralgia (both diagnoses based on the RDC/TMD).⁴¹ Indi-

viduals developing TMDs are also more likely to describe comorbidities such as headaches, muscle soreness, and other body pains.⁴²

In a more integrated model, it was investigated if the presence of comorbid conditions further modifies the phenotype of individuals with TMDs. This relationship was evaluated implementing a Multisystem Dysregulation Index that included sensory, autonomic, inflammatory, and psychologic domains due to their contribution in pain amplification.⁴³ Among individuals without comorbid persistent pain (only 8% among cases of the study population), the predominant dysregulation was in the sensory domain, which represented the presence of generalized somatic sensitization. Among those with one persistent painful comorbid condition (49%), the psychologic dysregulation was the only domain associated with the increased risk of having a TMD. For those individuals with two or more comorbid conditions (42%), a multisystem dysregulation was observed including sensory, psychologic, and autonomic domains, indicating that multisystem dysregulation is associated with common persistent pain conditions.⁴³

International comparisons of comorbid pain conditions among women with TMD pain were evaluated among women from Italy, Sweden, and Saudi Arabia. Using a case-control design and age-matched in the respective centers, it was found that comorbid pain prevalence, intensity, and disability differ among women from these cultures. The comorbid conditions studied were head, chest, back, and abdominal pain, and all comorbid conditions were consistently higher among the cases than the controls. The prevalence of back pain was higher among women from Saudi Arabia. Saudi Arabian women had more interference from the back pain than women from Sweden and Italy. Headache did not differ among the groups, but the intensity was lower among the women from Sweden.⁴⁴

Etiology of TMDs

No unambiguous universal cause of TMDs has been identified because determining causation requires more than phenotyping the conditions under study and/or describing their distribution based on observational studies. Nevertheless, the methodologic quality of such observational studies is key to determine their internal and external validity and therefore to transfer such knowledge to clinical care. For this reason, most of the factors discussed in this section are not proven causal, but associated with TMDs. Factors that may cause the onset of TMDs are called *initiating factors*, factors that increase the risk of TMDs are called *predisposing factors*, and factors that interfere with healing or enhance the progression of TMDs are called *perpetuating factors*. Under different circumstances, individual factors may serve any or all of these roles. There is not a single etiologic factor or a unique theoretical model that can explain the onset of TMDs.

Bone and TMJ soft tissue remodeling and muscle tone regulation are all adaptive physiologic responses to injury or change. Loss of structural integrity, altered function, or biomechanical stresses in the system can compromise adaptability and increase the likelihood of dysfunction or pathology.⁴⁵ Direct extrinsic trauma to any component of the masticatory system can spontaneously initiate loss of structural integrity and concomitantly alter function, thereby reducing the adaptive capacity in the system. In addition, there are other contributing anatomical, systemic, pathophysiologic, and psychosocial factors that may sufficiently reduce the adaptive capacity of the masticatory system and result in TMDs.

Trauma

Trauma is described as any force applied to the mastication structures that exceeds that of normal functional loading. Most trauma can be divided into three types: (1) the result of a

sudden and usually isolated blow to the structures (*direct trauma*), (2) that associated with a sudden blow but without direct contact to the affected structures (*indirect trauma*), and (3) the result of prolonged, repeated force over time (*microtrauma*).

Direct trauma

There is general agreement that direct trauma (ie, macrotrauma) to the mandible or the TMJ produces injury via impact and is accompanied in close temporal proximity with signs and symptoms of inflammation. If the forces lead to structural failure, loss of function may quickly follow. Direct trauma resulting in mandibular fracture in adults has been associated with increased signs and symptoms of TMDs; however, these may not result in patients seeking treatment.⁴⁶ In children, condylar and subcondylar fractures in girls, but not boys, were associated with increased TMD symptoms over time.⁴⁷ More significant fractures may result in disc displacement.⁴⁸ Patients with TMDs report physical trauma more often than non-TMD patients.⁴⁹ The accuracy of recall of TMD symptoms associated with a traumatic event may be compromised, making it difficult to clearly link the traumatic event with the symptom onset.⁵⁰ Other forms of trauma such as wide or prolonged mouth opening, third molar extraction, and intubation have been reported as associated with TMDs.^{51,52} Self-reported jaw injury due to yawning or prolonged opening is significantly higher in patients with TMDs.⁴⁹ Transient and permanent dysfunction of the TMJ after upper airway management procedures has been reported, but controlled trials and longitudinal studies are not available in the English-language literature.^{53,54}

Indirect trauma

Acceleration-deceleration (flexion-extension) injury (ie, whiplash) with no direct blow to the face may cause symptoms consistent with TMDs, but significant controversy persists

as to whether there could be a direct causal relationship. Prospective controlled studies both link and show limited risk for the development of TMD symptoms after whiplash.^{55,56} Review of the literature has highlighted these controversies; however, there is some evidence that postwhiplash TMDs can have a different and potentially more protracted clinical course than non-trauma-associated TMDs.⁵⁷⁻⁵⁹ Although symptoms in the mandible may be referred from injured cervical structures, a direct causal relationship between mandibular symptoms and indirect trauma has yet to be established.^{56,60,61} However, reports seem to indicate increased risk to developing orofacial pain, especially with increased severity of the indirect trauma.⁶²

Computer simulation suggests that low-velocity rear-end impact does not cause mandibular movement or stresses beyond the physiologic range.⁶³ In support of this finding, human volunteers in simulated rear-end crash tests failed to demonstrate mandibular movement beyond physiologic limits.⁶⁴ Thus, while evidence is lacking for a mandibular strain without a direct blow to the mandible following a low-velocity motor vehicle accident, there are recognized pathways of heterotopic pain from the cervical area to the trigeminal area.^{16,65} It is therefore not uncommon to observe symptoms of TMDs following acceleration-deceleration injury to the neck without direct trauma to the face or jaw. The etiologic significance of nonimpact injuries is uncertain, and much misinformation is being provided to patients without scientific studies to support the claims.

Microtrauma

Microtrauma has been hypothesized to originate from sustained and repetitious adverse loading of the masticatory system through postural imbalances or from parafunctional habits. It has been suggested that postural habits such as forward head position or phone-bracing may create muscle and joint

strain and lead to musculoskeletal pain—including headache—in the TMD patient.⁶⁶

Parafunctional habits have been most frequently assessed by indirect means such as self-report, questionnaires, reports by a bed-room partner, or tooth wear. These indirect measures of parafunctional habits have provided conflicting reports as to the relationship between TMD symptoms and the presence of parafunctional habits. When myofascial TMD patients were compared with controls using polysomnography, the tests did not confirm the patients' self-reports of more sleep bruxism than the controls.⁶⁷ Parafunctional habits such as teeth clenching, tooth grinding, lip biting, and abnormal posturing of the mandible are common and usually do not result in TMD symptoms, but they have been suggested as initiating or perpetuating factors in certain subgroups of TMD patients.^{14,68–75} Although the available research and clinical observations generally support this contention, the exact role of parafunctional habits in TMDs remains unclear because few studies have directly assessed these behaviors. Attrition severity secondary to bruxism cannot distinguish TMD patients from asymptomatic individuals, and muscle hyperactivity has not been shown to be associated with arthrogenous TMJ disorders.^{76–78} Furthermore, clenching does not cause neuromuscular fatigue because muscles compensate for sustained muscle activity by derecruitment of motor neurons or through slower firing rates.⁷⁹

Despite the lack of evidence that nonexperimentally induced parafunction or clenching can cause TMDs, some studies have shown that experimentally induced parafunction can result in transient pain similar to that reported by patients with TMDs.^{72,80–82} The impact of these studies is limited by their small sample size. The intensity and frequency of oral parafunctional activity may be exacerbated by stress and anxiety, sleep disorders, and medications (eg, neuroleptics, alcohol, and other substances), although the relationship between sleep bruxism and psychologic fac-

tors has been questioned.^{14,83,84} Some forms of masticatory muscle hyperactivity have been associated with emotional behavior and may be mediated via the cortex through the hypothalamus.⁸⁵ Intense and persistent parafunction can also occur in patients with neurologic disorders (eg, cerebral palsy) and extrapyramidal disorders (eg, orofacial dyskinesia and epilepsy).⁸⁶ Conversely, sleep bruxism has not been related to facial type or head form.⁸⁷

The most commonly believed indication of past sleep bruxism severity is dental attrition.⁸⁸ However, dental attrition can also be partly explained by overbite and overjet changes that correlate with age and sex, protrusive guidance schemes, dentofacial morphology, erosive diets, the bite force ability, and environmental factors.^{89–97} In addition, it is not clear whether sleep bruxism is a pathogenic disorder or a normal physiologic process. Recent evidence suggests that sleep bruxism may be associated with increasing salivation during sleep, resulting in lubrication of oropharyngeal structures, or with increasing the space of the upper airways to aid with airway patency, or both.^{98–101} Furthermore, it has been suggested that sleep bruxism plays a protective role as a compensatory mechanism to protect the airway during sleep-related breathing disorders.¹⁰² Therefore, the issue of whether or not sleep bruxism requires management without the presentation of significant problems is debatable. A more pragmatic approach may be to view this as an issue regarding “consequence management,” taking into account risk or side effect/benefit ratio.¹⁰³ Another problem arises when attrition is used to suggest current bruxism levels.⁷¹ Attrition appears to be episodic in nature and occurs in bursts caused by as yet unspecified factors, and thus any noted attrition may not necessarily represent ongoing habits.^{25,104} Continued research with more direct measurements of parafunction (eg, portable electromyography, sleep laboratory, and direct observation) will be necessary to clarify the specific role of current parafunction.^{105–107}

Anatomical factors

Skeletal factors

Skeletal factors include adverse biomechanical relationships that can be genetic, developmental, or iatrogenic in origin. Severe skeletal malformations, interarch and intraarch discrepancies, and past injuries to the teeth may play a role in TMDs, but this role may be less strong than previously believed. For example, while it is known that disc displacement is common in children with facial skeletal abnormalities such as retrognathia, it cannot be said that these anatomical anomalies are etiologic.¹⁰⁸ In addition, TMD patients with a disc displacement as well as other TMD patients generally do not have an increased prevalence of forward head posture.¹⁰⁹

A steep articular eminence has also been proposed as an etiologic factor in internal derangement of the TMJ. In asymptomatic individuals, a steeper eminence was associated with an increased posterior rotation of the disc, posing a potential anatomical risk factor.¹¹⁰ However, several studies have shown that in TMJs with disc displacement without reduction and TMJs with osseous changes, the eminence was less steep than in TMJs with disc displacement with reduction or TMJs without osseous changes, indicating adaptive remodeling.^{111–113} In addition, unilateral joint sounds were associated with the side with the less steep condylar movement path.¹¹⁴

Occlusal relationships

The dental profession has historically viewed occlusal variation as a primary etiologic factor for TMDs. Occlusal features such as working and nonworking posterior contacts and discrepancies between the retruded contact position (RCP) and intercuspal position (ICP) have been commonly identified as predisposing, initiating, and perpetuating factors. The current available evidence suggests that the influence of the occlusion on the onset and development of TMDs is low.^{115,116} Among the occlusal factors evaluated, loss of posterior

support and unilateral crossbite show some association across studies.¹¹⁵

Several occlusal factors (eg, large overjet, minimal anterior overlap and anterior skeletal open bite, unilateral posterior crossbite, occlusal slides greater than 2 mm, and lack of firm posterior tooth contact) were found to be more prevalent in patients than in convenience samples. However, this is possibly due to condylar positional changes following intracapsular alterations associated with the disease process itself. Therefore, these occlusal factors may be the result rather than the cause of the disease.^{115,117,118} Previous studies have lacked reliable occlusal measurement techniques and data collection methods, which may explain the diversity of some findings. Nevertheless, whether considered individually or simultaneously, little evidence is available to implicate occlusal factors in TMD etiology despite the historic views.¹¹⁸

Pathophysiologic factors

Systemic factors

Systemic pathophysiologic conditions may influence local TMDs and should generally be managed in cooperation with the patient's primary care physician or other medical specialists. These conditions can include degenerative, endocrine, infectious, metabolic, neoplastic, neurologic, rheumatologic, and vascular disorders. Systemic factors can act simultaneously at a central and local (ie, peripheral) level.^{119,120}

Generalized joint laxity (ie, hypermobility) has been cited as a possible contributing factor to TMDs and has proven to be significantly more prevalent in patients with internal derangements than with other types of TMDs or in normal controls.^{25,121–125} Altered collagen metabolism may also play a role in joint laxity, and the collagen composition in TMJs with painful disc displacement compared with asymptomatic joints has been found to differ.^{123,126}

Nevertheless, there is only a weak correlation between the mobility of peripheral joints or the trunk and mandibular mobility, and research has yet to demonstrate that joint laxity can predict the potential for developing TMDs.¹²⁷

Local (peripheral) factors

Local pathophysiologic factors of TMDs such as masticatory efficiency appear to be multifactorial and involve such a large span of individual variation that it is difficult to establish norms.¹²⁸ In addition, chewing force is also influenced by sex, age, and pain levels.^{129–135}

Masticatory muscle tenderness is not always related to variation in muscle activity or the site or side of reported tenderness.^{120,136–138} While the masseter muscle may react to proximal muscle pain, the anterior temporalis muscle does not, and any associations may be parallel developments rather than etiologic. Muscle tenderness does not appear to be the result of inflammation but is probably related to prolonged central hyperexcitability and altered CNS processing following peripheral tissue injury.¹³⁸ Cervical muscle activity has been shown to influence masticatory muscle activity, probably involving a primary afferent reflex response.^{139–141} Thus, a primary cervical or TMJ disorder may precipitate a secondary masticatory muscle condition. Muscle hyperalgesia can also result from TMJ inflammation.¹⁴²

Of great concern to the clinician is the distinction between pathologic and adaptive responses to disease in the TMJ. Histologic studies suggest that cartilage thickness and composition adapt to shearing stresses during functional loading.^{143,144} Maintenance of an intact articular surface is to be expected, even in the face of osteoarthritic changes, allowing for both stable morphologic relationships and histologic compatibility between the articulating components.^{118,145,146} Therefore, even though morphologic change is mostly irreversible, it usually achieves and maintains stability and should be considered adaptive.¹⁴⁷ The goal of treating osteoarthritic changes in this light

should not be to restore earlier morphology but to encourage the body's adaptive response to pathophysiologic processes.

In early disc derangements, signs of osteoarthritis are not apparent. Disc derangements with reduction may persist for many years without development of radiographically visible changes or symptoms.¹⁴⁸ Disc derangements in later stages with osteoarthritic changes occur possibly parallel but may also represent independent processes, and 50% will show some active cellular osteoblastic or osteoclastic activity.^{149,150} Osteoarthritic changes, alterations in synovial fluid viscosity, and inadequate or altered lubrication may initiate derangement of the TMJ articular disc.^{151,152} Synovial fluid analyses attempting to correlate biochemical signs of inflammation with pain reveal abnormal concentrations of plasma proteins or neurotransmitters and inflammatory cytokines.^{153–158} While still controversial, cytokine profiles of patients with intracapsular TMDs do appear to be different from controls.¹⁵⁹ With these as well as animal model studies, additional research in this area could have the potential for targeted therapeutic treatments in a subset of individuals with TMDs.

Frictional "sticking" of the disc has been proposed to cause internal derangement of the TMJ with the forces dependent on the type of clenching task, with the greater impact at ICP and during a unilateral molar clench.^{73,160,161} According to experimental models and animal studies, the forces are also increased by reduced congruity between the opposing surfaces and by flat unrounded surfaces.^{161–165} The forces are affected by disc thickness and area and by mandibular deformation during clenching.^{164,166} Interestingly, nonworking tooth contacts have been hypothesized to reduce loads within the joint and act as a stress breaker for the clenching forces.¹⁶¹ Intracapsular pressure may also affect TMDs.^{167,168} With joint movement, the alternating pressure acts as a pump for joint lubrication, nutrition, blood supply, drug delivery, waste removal, and even con-

dylar growth. Thus, any interruption through immobilization or prolonged clenching might have the potential to initiate or advance TMD signs and symptoms.

Female hormones might play a role in TMJ disc disease, but this has not been proven because the presence of both estrogen and progesterone receptors within the articular disc has been both confirmed and denied.^{169,170} Clinical randomized controlled trials (RCTs) indicate that estrogen does not play a role in the etiology of TMDs, whereas cohort studies and case-control studies show contrasting results.^{171–174} The etiologic explanations for progression from disc displacement to osteoarthritis and osteoarthritic changes are multifactorial and include failure of the reparative articular chondrocyte response due to metabolic dysfunction and relative or absolute overloading due to excessive mechanical forces leading to articular cartilage biochemical failure.^{45,175} Remodeling, in contrast, is a physiologic response to accommodate an altered disc position.¹¹⁸ Thus, it is probable that a mechanical breakdown in the articular disc (eg, a perforation) rather than an unusual disc position leads to osteoarthritis and/or osteoarthritic changes following disc displacement.¹⁷⁶ It is not certain, however, that all gross abnormalities of disc morphology will lead to osteoarthritis because one experimental animal study suggests that the TMJ may be capable of healing disc perforations within a relatively short time.¹⁷⁷ Mechanical stress may also lead to the accumulation of damaging free radicals in affected articular tissues of susceptible individuals. This condition is called *oxidative stress*.¹⁷⁸ Dijkgraaf et al¹⁷⁹ have proposed that free radicals may be responsible for the formation of adhesions in the TMJ by cross-linking of proteins.

Genetic factors

While the body of literature available with regard to genetic susceptibility for TMDs is an expanding field, genetic association studies have been limited. The relationship be-

tween catechol-O-methyltransferase (*COMT*) polymorphism, pain sensitivity, and the risk of TMD development has been evaluated, and three genetic variants (haplotypes) of the gene encoding *COMT* were identified and designated as “low pain sensitivity,” “average pain sensitivity,” and “high pain sensitivity.”¹⁸⁰ The haplotypes were associated with experimental pain sensitivity, and the presence of even a single “low pain sensitivity” haplotype was shown to reduce the risk of developing myogenous TMDs. Furthermore, the gene–environment interaction was illustrated by the significant role of stress, which doubles the rate of TMDs among those with low-activity *COMT* haplotypes.²² The most current data from the Orofacial Pain: Prospective Evaluation and Risk Assessment (OPPERA) trial did not demonstrate significant variation in TMD incidence by genetic polymorphisms from a panel of candidates’ putative genes but found evidence for genetic associations in several pronociceptive intermediate phenotypes and their contributing role.¹⁸¹ Single-nucleotide polymorphisms (SNPs) representing 358 genes involved in biologic systems associated with pain perception were identified. Specifically, SNPs had stronger associations with nonspecific orofacial symptoms, global psychologic symptoms, stress and negative affect, and heat and temporal summation. These included the following:

- The glucocorticoid receptor gene, which suggests a role of the hypothalamic-pituitary-adrenal system in chronic TMDs
- The serotonin receptor gene, indicating the influence in nociceptive and affective pathways
- The gene encoding the α subunit of the voltage-gated sodium channel NaV 1.1, which is involved in the generation and propagation of action potentials in sensory nerves
- A variation in a gene encoding angiotensin I-converting enzyme implicated in hypertension

- The prostaglandin-endoperoxide synthase 1 gene, a regulator of nociception and inflammatory response
- A variation in the gene encoding amyloid β (A4) precursor protein, which influences synapse formation and neuronal plasticity
- Multiple PDZ domain protein gene, influencing G-protein-coupled receptors involved in nociception and analgesia

These most extensive panel-related candidate genes support the strong indication that multiple genetic and biologic pathways contribute to the risk for TMDs.¹⁸¹

Psychosocial factors

Psychosocial factors include individual, interpersonal, and situational variables that impact the patient's capacity to function adaptively. General distress is the most salient single factor across most individuals with chronic TMD pain.¹⁸² General distress is readily assessed (see chapters 2 and 12), and certainly other factors may contribute actively to the measured distress, such as personality characteristics, enduring stressors, a physical response style to stress, or limited coping skills.^{183–188}

There is evidence that some patients with TMDs experience more anxiety than healthy control groups and that some TMDs and orofacial pain symptoms may be only one of several somatic manifestations of emotional distress.^{189–192} Some muscle pain may in fact be caused by excessive sympathetic nervous system activity as an overresponse to life stressors, and the attention focused on the pain can adversely affect the intensity of the pain.^{193–196} Patients with such complaints often have a history of other stress-related disorders.¹⁹² Depression and anxiety related to other major life events may alter the patient's perception of and tolerance of physical symptoms, causing them to seek more care for what is presented as a problem of the body.¹⁹⁷ Patients with chronic TMDs have been found to have

psychosocial and behavioral characteristics similar to patients with lower back pain and headache.^{198,199} In general, TMD patients are not significantly different from healthy individuals in personality type, and they do not differ from other pain patients in response to illness, attitudes toward health care, or ways of coping with stress.^{69,188,200–202} Any psychologic impairment may be merely associated with the presence of pain persistence.^{131,197,203}

Environmental contingencies can greatly complicate treatment by affecting an individual's perception of and responses to pain and disease. Some patients may experience a lessening of distress to the extent that psychogenic symptoms decrease or resolve preexisting psychologic and interpersonal conflicts. This primary gain of symptom formation is distinguished from the secondary gain of social benefits experienced by patients once a disorder is established.^{204–206} Secondary gain includes being exempt from ordinary daily responsibilities; being compensated monetarily from insurance or litigation; using the rationalization of "being ill" to avoid unpleasant tasks; and gaining attention from family, friends, or health care workers.^{206,207} What the clinician interprets as pain (eg, in response to a clinical examination procedure designed to evoke pain) may be less related to any local nociceptive mechanisms and more a function of pain behavior: how the individual presents his or her distress as motivated by factors beyond the stated complaint.

From the psychosocial domain, the OPPERA study group evaluated 26 psychosocial measures; among them, the frequency of somatic symptoms was the strongest predictor for TMD onset. Other contributors to a lesser degree were psychologic stress, anxiety, obsessive-compulsive feelings, and pain coping strategies.²⁰⁸ Using a case-control analytical approach as a foundation for their research, the OPPERA group reported that TMD cases are different than controls across multiple phenotypic domains including sociodemographic

factors, clinical variables, psychologic functioning, pain sensitivity, autonomic responses, and genetic associations. All of these elements are providing leading-edge information to the biologic pathways that may elucidate TMD pathophysiology.²⁰⁹

Diagnostic Classification of TMDs

The classification of TMDs is hampered by limited knowledge of the etiology and the natural progression of these disorders, and yet advancement in our knowledge is dependent on an accepted taxonomy and corresponding diagnostic criteria.¹⁷ Diagnostic criteria allow comparisons of patient populations in different studies and provide a common language for developing a conceptual framework to use in the clinic.²¹⁰ Any classification scheme or taxonomy must be considered an evolving framework that will be modified by new findings and with increased level of understanding. The following outlines are based on the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD; a revision of the RDC/TMD), which include the most common TMDs with sensitivity and specificity values, and the expanded taxonomy, which includes less common TMDs without validity estimates (Box 8-1).^{211,212}

TMJ disorders

Joint pain (ICD-10 M26.62)

Previously described as synovitis, capsulitis, and retrodiscitis, joint pain has been explained in the biomedical model as an inflammatory process of the synovial lining of the TMJ that can be due to infection, an immunologic condition secondary to cartilage degeneration, or trauma. Joint pain is characterized by localized pain that is exacerbated by function and parafunction. On occasion, there may be a fluctuating swelling that decreases the ability to occlude on the ipsilateral posterior teeth.

Arthralgia (ICD-10 M26.62)

This is pain of joint origin affected by jaw movement, function, or parafunction and replication of this pain with provocation testing, either during mandibular movement or palpation of the TMJs. Sensitivity is 0.89, and specificity is 0.98.

History is positive for both of the following:

- In the past 30 days, pain in the jaw, temple, in front of the ear, or in the ear with examiner confirmation of pain location in a masticatory structure
- Pain altered with jaw movement, function, or parafunction

Confirmation of the pain location in the TMJ area includes at least one of the following tests:

- Palpation of the lateral pole (0.5 kg pressure) or around the lateral pole (1.0 kg pressure)
- Maximum unassisted or assisted opening, right or left lateral movements, or protrusive movements

Examination of the TMJ elicits a report of familiar pain (defined as similar or like the pain the patient has experienced in the masticatory area palpated during the last 30 days).

Arthritis

This is pain of joint origin with clinical characteristics of inflammation or infection: edema, erythema, and/or increased temperature. It may arise in association with trauma. Associated symptoms can include occlusal changes such as ipsilateral posterior open bite if intra-articular swelling is present unilaterally. This disorder has also been referred to as *synovitis* or *capsulitis*; however, these terms limit the sites of nociception. With this localized condition, there should be no history of systemic inflammatory disease. Sensitivity and specificity have not been established.

Box 8-1 Expanded TMD taxonomy**Temporomandibular joint disorders**

1. Joint pain (*ICD-10* M26.62)
 - A. Arthralgia
 - B. Arthritis
2. Joint disorders
 - A. Disc-condyle complex disorders (*ICD-10* M26.62)
 - i. Disc displacement with reduction
 - ii. Disc displacement with reduction with intermittent locking
 - iii. Disc displacement without reduction with limited opening
 - iv. Disc displacement without reduction without limited opening
 - B. Other hypomobility disorders (*ICD-10* M26.61)
 - i. Adhesions/adherence
 - ii. Ankylosis
 - a. Fibrous ankylosis
 - b. Osseous ankylosis
 - C. Hypermobility disorders
 - i. Subluxation (*ICD-10* S03.0XXA)
 - ii. Luxation (*ICD-10* S03.0XXA)
 - a. Closed dislocation (*ICD-10* S03.0XXA)
 - b. Recurrent dislocation (*ICD-10* M26.69)
 - c. Ligamentous laxity (*ICD-10* M24.20)
3. Joint diseases
 - A. Degenerative joint diseases (*ICD-10* M19.91)
 - i. Osteoarthritis
 - ii. Osteoarthritis
 - B. Condylitis (*ICD-10* M26.69)
 - C. Osteochondritis dissecans (*ICD-10* M93.20)
 - D. Osteonecrosis (*ICD-10* M87.08)
 - E. Systemic arthritides (rheumatoid arthritis: *ICD-10* M06.9)
 - F. Neoplasm (benign: *ICD-10* D16.5; malignant: *ICD-10* C41.1)
 - G. Synovial chondromatosis (*ICD-10* D48.0)
4. Fractures
 - A. Closed fracture of condylar process (*ICD-10* S02.61XA)
 - B. Closed fracture of subcondylar process (*ICD-10* S02.62XA)
 - C. Open fracture of condylar process (*ICD-10* S02.61XB)
 - D. Open fracture of subcondylar process (*ICD-10* S02.62XB)

5. Congenital/developmental disorders
 - A. Aplasia (*ICD-10* Q67.4)
 - B. Hypoplasia (*ICD-10* M27.8)
 - C. Hyperplasia (*ICD-10* M27.8)

Masticatory muscle disorders

1. Muscle pain limited to the orofacial region
 - A. Myalgia (*ICD-10* M79.1)
 - i. Local myalgia
 - ii. Myofascial pain
 - iii. Myofascial pain with referral
 - B. Tendonitis (*ICD-10* M67.90)
 - C. Myositis
 - i. Noninfective (*ICD-10* M60.9)
 - ii. Infective (*ICD-10* M60.009)
 - C. Spasm (*ICD-10* M62.838)
2. Contracture
 - A. Muscle (*ICD-10* M62.40)
 - B. Tendon
3. Hypertrophy (*ICD-10* M62.9)
4. Neoplasms
 - A. Jaw
 - i. Malignant (*ICD-10* C41.1)
 - ii. Benign (*ICD-10* D16.5)
 - B. Soft tissues of head, face, and neck
 - i. Malignant (*ICD-10* C49.0)
 - ii. Benign (*ICD-10* D21.0)
5. Movement disorders
 - A. Orafacial dyskinesia
 - i. Abnormal involuntary movements (*ICD-10* R25.1 [tremor unspecified]; R25.2 [cramp and spasm]; R25.3 [fasciculations])
 - ii. Ataxia, unspecified (*ICD-10* R27.0); muscular incoordination (*ICD-10* R27.9)
 - iii. Subacute, due to drugs; oral tardive dyskinesia (*ICD-10* G24.01)
 - B. Oromandibular dystonia
 - i. Acute, due to drugs (*ICD-10* G24.02)
 - ii. Deformans, familial, idiopathic, and torsion dystonia (*ICD-10* G24.1)
6. Masticatory muscle pain attributed to systemic/central disorders
 - A. Fibromyalgia (*ICD-10* M79.7)
 - B. Centrally mediated myalgia (*ICD-10* M79.1)

Masticatory muscle disorders

1. Headache attributed to TMDs (*ICD-10* G44.89 or *ICD-10* R51)

Associated structures

1. Coronoid hyperplasia (*ICD-10* M27.8)

Note: This box was adapted from work performed by the International RDC-TMD Consortium sponsored by the International Association for Dental Research and the Special Interest Group on Orofacial Pain of the International Association for the Study of Pain.

History is positive for arthralgia as defined above as well as one of the following:

- Swelling, redness, and/or increased temperature in front of the ear
- Dental occlusal changes resulting from articular inflammatory exudate (eg, posterior open bite)

Examination is positive for arthralgia as defined above as well as one of the following:

- Presence of edema, erythema, and/or increased temperature over the TMJs
- Reduction in dental occlusal contacts noted between two consecutive measurements

Unilateral or bilateral posterior open bite must not be attributable to other causes. The patient is negative for rheumatologic disease, including those in systemic arthritides. The pain is not better accounted for by another pain diagnosis.

Joint disorders

Articular disc displacement is the most common TMJ arthropathy and is characterized by several stages of clinical dysfunction that involve the condyle-disc relationship. It is characterized by an abnormal relation or misalignment of the articular disc relative to the condyle. Although posterior and mediolateral displacements of the articular disc have been described, the usual direction for displacement is in an anterior or anteromedial direction.^{213–220} Nevertheless, pain or mandibular movement symptoms are not specific for disc derangement disorders, and the disc position is not related to any presenting symptoms.^{221,222}

The causes of disc displacement are not agreed upon; however, it is postulated that in the majority of cases, elongated or torn ligaments binding the disc to the condyle permit the disc to displace.²²³ Lubrication impairment

is also suggested as a possible etiologic factor of disc displacement.^{73,152} Disc displacement is subdivided into disc displacement with reduction and disc displacement without reduction.

Disc-condyle complex disorders

Disc displacement with reduction (ICD-10 M26.63)

This is an intracapsular biomechanical disorder involving the condyle-disc complex: In the closed mouth position, the disc is in an anterior position relative to the condyle, and the disc reduces upon opening of the mouth. Medial and lateral displacement of the disc may also be present. Clicking, popping, or snapping noises may occur with disc reduction. Using MRI as the reference standard, sensitivity is 0.34, and specificity is 0.92. Although not required for this diagnosis and without diagnostic validity, elimination of the opening and closing noise, if present, with protrusion can help corroborate this diagnosis.

History is positive for the following:

- In the last 30 days, any noise(s) present with jaw movement or function, or patient report of joint sounds during the examination

Examination is positive for at least one of the following:

- Both an opening and closing clicking, popping, or snapping noise detected with palpation during at least one of three repetitions of jaw opening and closing
- Either an opening or closing clicking, popping, or snapping noise detected with palpation during at least one of three repetitions of opening and closing and a clicking, popping, and/or snapping noise detected with palpation during at least one of three repetitions of left lateral, right lateral, or protrusive movements

When this diagnosis needs to be confirmed, then imaging analyses criteria, using TMJ MRI, are positive for both of the following:

- In the maximum intercuspal position, the posterior band of the disc is located anterior to the 11:30 position, and the intermediate zone of the disc is anterior to the condyle and the articular eminence.
- On full opening, the intermediate zone of the disc is positioned between the condyle and the articular eminence.

Disc displacement with reduction with intermittent locking (ICD-10 M26.63)

This is an intracapsular biomechanical disorder involving the condyle-disc complex: In the closed mouth position, the disc is in an anterior position relative to the condyle, and the disc intermittently reduces with opening of the mouth. When the disc does not reduce with opening of the mouth, intermittent limited mandibular opening occurs. When the limited opening occurs, a maneuver may be needed to unlock the TMJ. Medial and lateral displacement of the disc may also be present. Clicking, popping, or snapping noises may occur with disc reduction. Although not required for this diagnosis, occurrence of intermittent closed lock during the clinical examination can help corroborate this diagnosis. Using MRI as the reference standard, sensitivity is 0.38, and specificity is 0.98.

History is positive for both of the following:

- In the last 30 days or during the examination itself, any noises present with jaw movement or function
- In the last 30 days, report of intermittent locking with limited opening or evidence of intermittent locking during clinical examination

Examination is positive for the following:

- Disc displacement with reduction as defined above

When this diagnosis needs to be confirmed, the imaging analysis criteria are the same as for disc displacement with reduction. If locking occurs during imaging, then an imaging-based diagnosis of disc displacement without reduction will be rendered, and clinical confirmation of reversion to intermittent locking is needed.

Disc displacement without reduction with limited opening (ICD-10 M26.63)

This is an intracapsular biomechanical disorder involving the condyle-disc complex: In the closed mouth position, the disc is in an anterior position relative to the condyle and the disc does not reduce with opening of the mouth. Medial and lateral displacement of the disc may also be present. This disorder is associated with limited mandibular opening that does not reduce with the clinician or patient performing a manipulative maneuver. This is also referred to as *closed lock*. Using MRI as the reference standard, sensitivity is 0.80, and specificity is 0.97.

History is positive for both of the following:

- Jaw lock or catch so that it will not open all the way
- Limitation in jaw opening severe enough to interfere with the ability to eat

Examination is positive for the following:

- Maximum assisted opening (passive stretch) < 40 mm including vertical incisal overlap

When this diagnosis needs to be confirmed, then imaging analysis criteria, using TMJ MRI, are positive for both of the following:

- In the maximum intercuspal position, the posterior band of the disc is located anterior to the 11:30 position, and the intermediate zone of the disc is anterior to the condyle and the articular eminence.

- On full opening, the intermediate zone of the disc is positioned anterior to the condyle.

Disc displacement without reduction without limited opening (ICD-10 M26.63)

This is an intracapsular biomechanical disorder involving the condyle-disc complex: In the closed mouth position, the disc is anterior relative to the condyle, and the disc does not reduce with opening of the mouth. Medial and lateral displacement of the disc may also be present. This disorder is not associated with limited mandibular opening. Using MRI as the reference standard, sensitivity is 0.54, and specificity is 0.79.

History is the same as defined for disc displacement without reduction with limited opening.

Examination is positive for the following:

- Maximum assisted opening (passive stretch) > 40 mm including vertical incisal overlap

When this diagnosis needs to be confirmed, then imaging analysis criteria are the same as for disc displacement without reduction with limited opening.

Other hypomobility disorders (ICD-10 M26.61)

Intra-articular fibrous adhesions and ankyloses are characterized by a restricted mandibular movement with deflection to the affected side on opening that may occur as a long-term sequela of trauma, including mandibular fracture. In case of bilateral involvement, asymmetries in mandibular movements during clinical examination will be less pronounced or absent. The diagnostic criteria of mandibular movement asymmetries are for unilateral causes of hypomobility. Hypomobility is firm and unyielding because of intra-articular fibrous adhesions, more widespread fibrotic changes in the capsular ligaments (fibrous ankylosis), and/or, less

frequently, the formation of a bony mass that results in fusion of the joint components (bony ankylosis). The condition is usually not associated with pain. The most frequent cause of TMJ ankylosis is macrotrauma; less frequent causes are infection of the mastoid or middle ear, systemic disease, and inadequate surgical treatment of the condylar area.

Adhesions and adherence

Fibrous adhesions within the TMJ are thought to occur mainly in the superior compartment of the TMJ. They produce decreased movement of the disc-condyle complex. Adhesions may occur secondary to joint inflammation that results from direct trauma, excessive loading, or systemic conditions such as a polyarthritic disease. They are typically associated with disc-condyle complex disorders.

History is positive for both of the following:

- No history of TMJ clicking (historically to differentiate from disc displacement without reduction with limited opening)
- History of loss of jaw mobility

Examination is positive for all of the following:

- Limited range of motion on opening
- Uncorrected deviation of the jaw to the affected side on opening if present unilaterally
- Marked limited laterotrusion to the contralateral side if unilateral

When this diagnosis needs to be confirmed, arthrography, MRI, or arthroscopy may show the presence of adhesions. Sensitivity and specificity have not been established.

Ankylosis

TMJ ankyloses are differentiated by the type of tissues that are causing them: fibrous or bony. In fibrous ankylosis, there are no gross bony changes and no radiographic findings other

than absence of ipsilateral condylar translation on opening. Bony ankylosis is characterized by the union of the bones of the TMJ as a result of bone cell proliferation; this may cause complete immobility of that joint. It is characterized by radiographic evidence of bone proliferation with marked deflection to the affected side and marked limited laterotrusion to the contralateral side. Sensitivity and specificity have not been established for these disorders.

Fibrous ankylosis

History is positive for the following:

- History of progressive loss of jaw mobility

Examination is positive for all of the following:

- Severe limited range of motion on opening
- Uncorrected jaw deviation to the affected side
- Marked limited laterotrusion to the contralateral side

Computed tomography (CT) or cone beam CT (CBCT) is positive for both of the following:

- Imaging findings of decreased ipsilateral condylar translation on opening
- Imaging findings of a joint space between ipsilateral condyle and eminence

Bony ankylosis

History is positive for the following:

- History of progressive loss of jaw mobility

Examination is positive for the following:

- Absence of or severely limited jaw mobility with all movements

CT/CBCT is positive for the following:

- Imaging-based evidence of bone proliferation with obliteration of part or all of the joint space

Hypermobility disorders (closed dislocation: *ICD-10 S03.0XXA*; recurrent dislocation: *ICD-10 M26.69*; ligamentous laxity: *ICD-10 M24.20*)

Hypermobility disorders include two types of TMJ dislocations in which the disc-condyle complex is positioned anterior to the articular eminence and is unable to return to a closed position without a specific maneuver by the patient (ie, subluxation or partial dislocation) or by the clinician (ie, luxation or dislocation). The latter disorder is also referred to as *open lock*. Note that the condyle is frequently anterior to the eminence at full mouth opening and thus by itself is not a predictor of hypermobility disorders. The duration of dislocation may be momentary or prolonged. Pain may occur at the time of dislocation with residual pain following the episode.

Subluxation (ICD-10 S03.0XXA)

This is a condition involving the disc-condyle complex and the articular eminence. In the open mouth position, the disc-condyle complex is positioned anterior to the articular eminence and is unable to return to normal closed mouth position without a manipulative maneuver by the patient. When the patient needs the assistance of the clinician to reduce the dislocation and normalize the jaw position, it is called *luxation* or *open lock*. Using history only, sensitivity is 0.98, and specificity is 1.00.

History is positive for both of the following:

- In the last 30 days, jaw locking or catching in a wide open mouth position, even for a moment, so the patient could not close from the wide open position

- Inability to close the mouth from wide opening without a self-maneuver

No examination findings are required. If the patient presents with this disorder, he or she is then found clinically positive for inability to return to a normal closed mouth position without manipulative patient maneuver.

Luxation (ICD-10 S03.0XXA)

This is a condition in which the disc-condyle complex is positioned anterior to the articular eminence and is unable to return to the fossa without a specific manipulative maneuver by a clinician. This is also referred to as *open lock*. Sensitivity and specificity have not been established.

History is positive for both of the following:

- Report of inability to close from wide opening
- Report that mouth closing can be achieved only with a specific mandibular maneuver by the clinician

Examination is positive for one of the following persistent presentations:

- Wide open mouth
- Protruded jaw position
- Lateral position to the contralateral side if unilateral

When this diagnosis needs to be confirmed, CT/CBCT or MRI scans are positive for the following:

- The condyle is anterior to the articular eminence with the patient attempting to close the mouth.

Joint diseases

Osteoarthritis (ie, osteoarthrosis or DJD) is defined as a degenerative condition of the joint characterized by deterioration and abrasion of articular tissue and concomitant remodel-

ing of the underlying subchondral bone due to overload of the remodeling mechanism. The progressive loss of articular cartilage in the osteoarthritic TMJ results from an imbalance between predominantly chondrocyte-controlled reparative and degradative processes.²²⁴ The process accelerates as proteoglycan depletion, collagen fiber network disintegration, and fatty degeneration weaken the functional capacity of the articular cartilage. Different kinds of biochemical markers have been determined in the synovial fluid of TMJs with osteoarthritis. These include interleukin-6 (IL-6), tissue inhibitor metalloproteinase-1 (TIMP-1), matrix metalloproteinases, heat shock protein (HSP), transforming growth factor β 1 (TGF- β 1), bone morphogenetic protein 2 (BMP-2), chondroitin-4-sulfate (C4S) and chondroitin-6-sulfate (C6S), keratan sulfate (KS), and human leucocyte antigen D related (HLA-DR).^{225–235} The clinical and diagnostic value of these markers remains to be evaluated because similar markers have also been present in other joint diseases. Radiographic evidence typically lags behind articular tissue changes.²³⁶ The early changes in the synovial membrane, such as synovial intima hyperplasia, cell hypertrophy with subsequent loss of fibrous material in the intima matrix, and articular cartilage are only detectable with biopsy and arthroscopy.^{175,237,238} Thus, osteoarthrosis frequently escapes early clinical detection.²³⁹

DJD (ICD-10 M19.91; localized/primary)

Degenerative disorders involving the joint are characterized by deterioration of articular tissue with concomitant osseous changes in the condyle and articular eminence. Using CT/CBCT as the reference standard, sensitivity is 0.55, and specificity is 0.61.

History is positive for one of the following:

- In the past month, any joint noises present with jaw movement or function
- Patient report of any noises during the examination

Examination is positive for the following:

- Crepitus detected with palpation during at least one of the following: maximum unassisted opening, maximum assisted opening, right or left lateral movements, or protrusive movements

CT/CBCT is positive for at least one of the following:

- Subchondral cyst
- Erosion
- Generalized sclerosis
- Osteophyte

Flattening and/or cortical sclerosis are considered indeterminate findings for DJD and may represent normal variation, aging, remodeling, or a precursor to frank DJD.

Condylolysis/idiopathic condylar resorption (ICD-10 M26.69)

This is an idiopathic degenerative condition leading to the loss of condylar height and a progressive anterior open bite. The condition occurs spontaneously, is mainly bilateral, and occurs primarily in adolescent and young adult females.²¹² The presence of pain or joint sounds is variable. In early stages, dental occlusal changes may not be evident, but imaging findings would be positive. It has been suggested that it may be a severe form of DJD and that low estrogen levels may be implicated.²⁴⁰ Sensitivity and specificity have not been established.

History is positive for the following:

- Progressive dental occlusal changes

Examination is positive for both of the following:

- Anterior open bite
- Evidence of progressive dental occlusal changes with either occlusal facets that

cannot be approximated or change in sequential occlusal measurement over time based on overbite, overjet, or intercuspal contacts

Imaging includes CT/CBCT evidence of partial or total condylar resorption or change with sequential imaging over time from lateral cephalometric images, which may include clockwise mandibular rotation, increase in mandibular plane angle, or increased A point–nasion–B point. Serologic tests for rheumatologic disease, including systemic arthritides, must be negative.

Osteochondritis dissecans (ICD-10 M93.20)

This is a joint condition in which a piece of cartilage and a small bone fragment break loose from the end of the bone and result in loose osteochondral fragments within the joint. The pathophysiology is unclear. It usually occurs in the knee and elbow and is often related to sports. Case reports describe the condition in the TMJ, but little is known about signs and symptoms. Sensitivity and specificity have not been established.

History is positive for any of the following:

- Arthralgia as previously defined
- Joint noises with mandibular movement or swelling

Examination is positive for one of the following:

- Same clinical findings as operationalized for arthralgia
- Crepitus detected by the examiner during palpation or reported by patient during mandibular movements
- Maximum assisted opening plus vertical overlap < 40 mm
- Swelling around the affected joint

CT/CBCT will provide positive findings for loose osteochondral fragments within the

joint. Serologic tests for rheumatologic disease, including systemic arthritides, must be negative.

Osteonecrosis (ICD-10 M87.08)

Osteonecrosis is a painful condition most commonly affecting the ends of long bones such as the femur. Other common sites include the humerus and the knees. The condition is found in the mandibular condyle on MRI as decreased signal in T1-weighted or proton density images and on T2-weighted images (sclerosis pattern) and can be combined with increased signal on T2 images (edema). The cause, clinical significance, and the need for treatment are unknown.

To diagnose osteonecrosis, the patient must fulfill criteria for arthralgia as previously defined, and imaging must show a decreased signal in T1-weighted or proton density MR images and can be combined with an increased signal on T2-weighted images. In addition, laboratory testing will confirm negative serologic results for rheumatologic disease. Sensitivity and specificity have not been established.

Systemic arthritides (rheumatoid arthritis: ICD-10 M06.9)

This is joint inflammation resulting in pain or structural changes caused by a generalized systemic inflammatory disease, including rheumatoid arthritis, juvenile idiopathic arthritis, spondyloarthropathies (eg, ankylosing spondylitis, psoriatic arthritis, infectious arthritis, Reiter syndrome), and crystal-induced disease (eg, gout, chondrocalcinosis). Other rheumatologically related diseases that may affect the TMJ include autoimmune disorders and other mixed connective tissue diseases (eg, scleroderma, Sjögren syndrome, lupus erythematosus).²⁴¹ This group of arthritides therefore comprises multiple diagnostic categories that are best diagnosed and managed by rheumatologists regarding the general or systemic therapy. Clinical signs and symp-

toms of an ongoing chronic TMJ inflammation are variable between patients and within a patient over time. They can vary from no signs or symptoms to only pain to only swelling and exudate to only tissue degradation to only growth disturbance. Resorption of condylar structures may be associated with malocclusion such as a progressive anterior open bite. A diagnostic instrument should aim to identify patients with chronic inflammation early and accurately, should not exclude patients with chronic arthritis of long duration, and should not only cover rheumatoid arthritis but the whole range of chronic inflammatory states. Imaging in early stages may not demonstrate osseous findings. Sensitivity and specificity have not been established.

History is positive for both of the following:

- Rheumatologic diagnosis of a systemic inflammatory joint disease
- TMJ pain or noises present in the past month or TMJ pain that worsens with the episodes and exacerbations of the systemic inflammatory joint disease

Examination is positive for both of the following:

- Rheumatologic diagnosis of a systemic joint disease
- Arthritis signs and symptoms as defined previously or crepitus detected with palpation during maximum unassisted and assisted opening, lateral, and protrusive movements

Imaging criteria are the same as for DJD; CT/CBCT is positive for at least one of the following:

- Subchondral cyst
- Erosion
- Generalized sclerosis
- Osteophyte

Neoplasm (TMJ) (benign: ICD-10 D16.5; malignant: ICD-10 C41.1)

A *neoplasm* is new, often uncontrolled growth of abnormal tissue, in this case arising or involving the TMJ or supporting structures. Neoplasms in this area may be benign, malignant, or metastatic. Although neoplasia as an underlying cause of TMJ dysfunction is rare, it is well known in the literature.²⁴² Approximately 3% of malignant neoplasia metastasizes to the jaws.^{243,244} Neoplasia most frequently extending to the TMJ region causing pain and dysfunction are squamous cell carcinomas of the maxillofacial region and primary nasopharyngeal tumors.^{16,245–253} Neoplasia arising in the parotid gland, such as adenoid cystic carcinomas and mucoepidermoid carcinomas, may produce TMJ pain and dysfunction.^{254–256} The most common signs and symptoms are reduced opening, crepitation, occlusal changes, pain with function, and swelling.²⁵⁷ If the condyle is involved, there is frequently development of a facial asymmetry with a midline shift as that seen in condylar hyperplasia.²⁵⁸ The most common treatment is surgery. Diagnostic imaging and biopsy are essential when a neoplasm is suspected. Sensitivity and specificity have not been established.

Synovial chondromatosis (ICD-10 D48.0)

Synovial chondromatosis is a cartilaginous metaplasia of the mesenchymal remnants of the synovial tissue of the joint. Its main characteristic is the formation of cartilaginous nodules that may be pedunculated and/or detached from the synovial membrane, becoming loose bodies within the joint space. Calcification of the cartilage can occur (ie, osteochondromatosis). The disease may be associated with malocclusion, such as a progressive ipsilateral posterior open bite. Imaging is needed to establish the diagnosis. Sensitivity and specificity have not been established.

History must be positive for at least one of the following:

- Report of preauricular swelling
- Arthralgia as previously defined
- Progressive limitation in mouth opening
- Presence of joint noises in the last month

Examination must confirm at least one of the following:

- Preauricular swelling
- Arthralgia as previously defined
- Maximum assisted opening (passive stretch) < 40 mm, including the vertical incisal overlap
- Crepitus as per DJD

MRI or CT/CBCT of the TMJ must be positive for at least one of the following:

- MRI: multiple chondroid nodules, joint effusion, and amorphous iso-intensity signal tissues within the joint space and capsule
- CT/CBCT: loose calcified bodies in the soft tissues of the TMJ

Histologic examination confirms cartilaginous metaplasia.

Fractures

Direct traumatic force can injure all related bony components of the masticatory system (ie, temporal bone, maxilla, zygoma, sphenoid bone, and mandible). This trauma can be related to the following conditions: fracture, dislocation, contusion, or laceration of articular surfaces, ligaments, and disc, with or without intraarticular hemarthrosis. Sequelae could include adhesions, ankylosis, occlusal abnormalities, or joint degeneration.^{167,259} Patients with nonsurgically treated dislocated fractures may be prone to symptoms of TMDs, functional disorders, and occlusal disorders.²⁵⁹ Fractures of the condylar process may result in facial asymmetry; in general, there are greater skeletal changes when the fracture occurs earlier in life. Closed treatments have report-

edly also resulted in facial asymmetries, even in adults.²⁶⁰ Sensitivity and specificity have not been established.

Examples of fractures are the following:

- Closed fracture of condylar process (*ICD-10 S02.61XA*)
- Closed fracture of subcondylar process (*ICD-10 S02.62XA*)
- Open fracture of condylar process (*ICD-10 S02.61XB*)
- Open fracture of subcondylar process (*ICD-10 S02.62XB*)

History must be positive for both of the following:

- Trauma to the orofacial region
- A preauricular swelling, arthralgia as previously defined, or limited mouth opening

Examination is positive for at least one of the following:

- Preauricular swelling
- Arthralgia as previously defined
- Maximum assisted opening (passive stretch) < 40 mm including vertical incisal overlap

Imaging is positive for evidence of fracture.

Congenital/developmental disorders

Aplasia (*ICD-10 Q67.4*)

Aplasia is defined as a typically unilateral absence of the condyle and incomplete development of the articular fossa and eminence, resulting in facial asymmetries. It is commonly associated with other congenital anomalies (eg, oculo-auriculo-vertebral spectrum [Goldenhar syndrome], hemifacial microsomia, and mandibulofacial dysostosis [Treacher Collins syndrome]). It is occasionally bilateral, and in such cases asymmetry is not present, but micrognathia is the dominant clinical manifestation. The condition may be associated

with malocclusion, which may include open bite. Sensitivity and specificity have not been established.

History must be positive for both of the following:

- Progressive development of mandibular asymmetry or micrognathia from birth or early childhood
- Development of malocclusion, which may include posterior open bite

Examination is positive for both of the following:

- Confirmation of mandibular asymmetry, with deviation of the chin to the affected side or micrognathia
- Inability to detect the condyle upon palpation during mandibular movements.

Imaging will show both of the following:

- Severe hypoplasia of the fossa and eminence
- Aplasia of the condyle

Hypoplasia (*ICD-10 M27.8*)

Hypoplasia is defined as incomplete development or underdevelopment of the cranial bones or the mandible. Growth is proportionately reduced and less severe than in aplasia. This condition bridges the continuum from aplasia to normal condylar size. Condylar hypoplasia can be secondary to facial trauma. The condition may be associated with malocclusion, which may include open bite. Sensitivity and specificity have not been established.

History must be positive for both of the following:

- Progressive development of mandibular asymmetry or micrognathia from birth or early childhood
- Development of malocclusion, which may include posterior open bite

Examination must confirm this history.

Imaging using CT/CBCT will show at least one of the following:

- Hypoplasia of the fossa
- Hypoplasia of the condyle
- Shortened mandibular ramus height

Hyperplasia (ICD-10 M27.8)

Hyperplasia is an overdevelopment of the cranial bones or mandible. It is a nonneoplastic increase in the number of normal cells. It can occur unilaterally or bilaterally as a localized enlargement such as condylar hyperplasia, or as an overdevelopment of the entire mandible or side of the face. Sensitivity and specificity have not been established.

To diagnose hyperplasia, the history must be positive for progressive development of mandibular or facial asymmetry, and the examination must confirm this history. Imaging using panoramic radiography and/or CT/CBCT and single-photon emission CT are positive for the following:

- Asymmetry in mandibular ramus height
- Increased uptake of technetium-99m hydroxyl diphosphonate on bone scintigraphy scan (nuclear imaging)

Masticatory muscle disorders

The mechanisms that produce pain in skeletal muscles are still not well understood. Overuse of a normally perfused muscle or ischemia of a normally working muscle may cause pain.^{261–264} Sympathetic and fusimotor reflexes can produce changes in the blood supply and muscle tone.^{265,266} Furthermore, different psychologic or emotional states can alter muscle tone.^{267,268} Neurons that mediate pain from skeletal muscles are subject to strong modulatory influences. Endogenous substances (eg, bradykinin, serotonin, prostaglandins, neuropeptides, and substance P) can sensitize the nociceptive endings very easily. Painful muscle conditions

not only lead to increased sensitivity of peripheral nociceptors but also produce hyperexcitability in the central nervous system, resulting in central sensitization presenting with localized hyperalgesia and allodynia.^{34,261,269–271}

Some systemic conditions that produce muscle pain are polymyalgia rheumatica, polymyositis, dermatomyositis, lupus erythematosus, and fibromyalgia (ie, chronic widespread pain). Fibromyalgia is of particular interest because it may easily be confused with a regional masticatory muscle disorder. When fibromyalgia is suspected, a referral to a rheumatologist is necessary.

Muscle pain limited to the orofacial region

Myalgia (ICD-10 M79.1)

Pain of muscle origin is modified by jaw movement, function, or parafunction, and replication of this pain is elicited with provocation testing of the temporalis or masseter muscles, which are the muscles involved with highest prevalence. Although not required in the criteria, a positive finding with the specified provocation tests when examining the other masticatory muscles can help to corroborate this diagnosis if the location of the pain associated with the chief complaint is in these muscles; limited mandibular range of motion may also be present. Hypothetically, based on the work by the validation research group and later on by the DC/TMD international community, three subtypes of myalgia can be identified, but only myalgia and myofascial pain with referral are the clinical diagnoses with diagnostic validity values; the other two diagnoses—local myalgia and myofascial pain with spreading—do not have sensitivity and specificity estimates.

History must be positive for both of the following:

- Pain in the jaw, temple, ear, or in front of the ear in the last 30 days.
- Pain is modified by jaw function or parafunction.

In addition, the clinical examination will reveal confirmation of the localization of the pain in the masticatory muscle structure, confirmed by the examiner, and report of familiar pain during vertical mandibular movements or palpation of the masticatory muscles. The sensitivity and specificity estimates are 0.90 and 0.99, respectively.

Local myalgia

This involves pain of muscle origin plus a report of pain localized only to the site of palpation (immediate site to stimulation). Limitation of mandibular movements secondary to pain may be present. Sensitivity and specificity have not been established. The criterion for this diagnostic group limits the familiar pain to be provoked only with palpation and not with mandibular movement.

Myofascial pain with spreading

This involves pain of muscle origin plus a report of pain spreading beyond the location of the palpating fingers but within the boundary of the masticatory muscle being examined. Limitation of mandibular movements secondary to pain may be present. Sensitivity and specificity have not been established.

To diagnose myofascial pain with spreading, the patient must have local myalgia, and the examination of the temporalis or masseter muscle must confirm both of the following:

- Familiar muscle pain with palpation
- Pain with muscle palpation with spreading of the pain beyond the location of palpation but within the boundary of the palpated muscle

Note: Other masticatory muscles may be examined as required.

Myofascial pain with referral

This involves pain of muscle origin as defined for myalgia plus a referral of pain beyond the boundary of the masticatory muscles being

palpated, for example, to the ear, tooth, or eye; spreading may be present. The sensitivity and specificity values are 0.86 and 0.98, respectively.

To diagnose myofascial pain with referral, the patient must have myalgia, and the examination of the temporalis or masseter muscle must confirm both of the following:

- Familiar muscle pain with palpation
- Pain with muscle palpation beyond the boundary of the muscle

Other masticatory muscles may be examined as required.

Tendonitis (ICD-10 M67.90)

Tendonitis involves pain of tendon origin affected by jaw movement, function, or parafunction and replication of this pain with provocation testing of the masticatory tendon. Limitation of mandibular movements secondary to pain may be present. The temporalis tendon is a common site of tendonitis with referred pain to the teeth or other structures. Sensitivity and specificity have not been established.

To diagnose tendonitis, the patient must have myalgia as previously defined, and the examination must confirm the diagnosis of myalgia but restricted to the temporalis tendon. This condition could also apply to other masticatory muscle tendons.

Myositis (noninfective: ICD-10 M60.9; infective: ICD-10 M60.009)

This involves pain of muscle origin with clinical characteristics of inflammation or infection: edema, erythema, and/or increased temperature. It generally arises acutely following direct trauma of the muscle or from infection or chronically with autoimmune disease. Limitation of unassisted mandibular movements secondary to pain is often present. Calcification of the muscle can occur (ie, myositis ossificans). Sensitivity and specificity have not been established.

To diagnose myositis, the patient must have local myalgia, and the examination of the temporalis or masseter muscle must confirm both of the following:

- Local myalgia
- Presence of edema, erythema, and/or increased temperature over the muscle

In addition, serologic tests may reveal elevated enzyme levels (eg, creatine kinase), markers of inflammation, and the presence of autoimmune diseases. Other masticatory muscles may be examined as required.

Spasm (ICD-10 M62.838)

This is a sudden, involuntary, reversible tonic contraction of a muscle. Acute malocclusion may be present. Sensitivity and specificity have not been established.

To diagnose a spasm, the patient must report the following:

- Immediate onset of muscle pain modified by function and parafunction as operationalized in myalgia
- Immediate report of limited range of jaw motion

In addition, the examination must confirm both of the following:

- Myalgia that may include all masticatory muscles
- Limited range of jaw motion in the direction that elongates the affected muscle (eg, for jaw closers, opening will be limited to < 40 mm; for the lateral pterygoid muscle, ipsilateral movement will be limited to < 7 mm)

When this diagnosis needs to be confirmed, laboratory testing will confirm elevated electromyographic activity compared with the contralateral unaffected muscle. Sensitivity and specificity have not been established.

Contracture (ICD-10 M62.40)

Contracture is the shortening of a muscle due to fibrosis of tendons, ligaments, or muscle fibers. It is usually not painful unless the muscle is overextended. A history of radiation therapy, trauma, or infection is often present. Sensitivity and specificity have not been established. To diagnose contracture, the patient must have progressive loss of range of motion, and the examination must confirm that unassisted and assisted jaw movements are limited such that maximum assisted opening is < 40 mm. It must also be associated with a hard end feel that has been operationalized as having unyielding resistance to assisted movements as felt by the clinician.

Hypertrophy (ICD-10 M62.9)

Hypertrophy is enlargement of one or more masticatory muscles. It is usually not associated with pain and can be secondary to overuse and/or chronic tensing of the muscle(s). Some cases are familial or genetic in origin. Sensitivity and specificity have not been established. To diagnose hypertrophy, the patient must have enlargement of one or more masticatory muscles as evidenced from photographs or previous records, and the examination must confirm this enlargement. Diagnosis is based on the clinician's assessment of muscle size and requires consideration of craniofacial morphology and ethnicity.

Neoplasm (soft tissues of head, face, and neck) (benign: ICD-10 D21.0; malignant: ICD-10 C49.0)

Neoplasms of the masticatory muscles result from tissue proliferation with histologic characteristics and may be benign (eg, myoma), malignant (eg, rhabdomyosarcoma), or metastatic. They are uncommon. They may present with swelling, spasm, pain during function, limited mouth opening, and/or sensory-motor changes (eg, paresthesias). Diagnostic imaging (typically using CT/CBCT and/or MRI) and biopsy are essential when a neoplasm is sus-

pected. Sensitivity and specificity have not been established.

Movement disorders

Orofacial dyskinesia

The *ICD-10* codes for the different types of orofacial dyskinesia are as follows:

- Tremor unspecified: *ICD-10* R25.1
- Cramp and spasm: *ICD-10* R25.2
- Fasciculations: *ICD-10* R25.3
- Ataxia, unspecified: *ICD-10* R27.0
- Muscular incoordination: *ICD-10* R27.9
- Subacute, due to drugs; oral tardive dyskinesia: *ICD-10* G24.01

Orofacial dyskinesia involves involuntary, mainly choreatic (dancelike) movements that may involve the face, lips, tongue, and/or jaw. The disorder may result in traumatic injury to the oral mucosa or tongue. It is more common with advancing age and in patients with a history of using neuroleptic medications and/or associated with traumatic brain injury, psychiatric conditions, or other neurologic disorders (eg, Wilson disease). Reduction or discontinuation of the movement pattern could occur when the mouth or face receives sensory stimulation (*sensory trick*). Sensitivity and specificity have not been established.

To allocate these diagnoses, the patient must provide a positive history of neurologic diagnosis of dyskinesia in the orofacial region and history components of myalgia and/or arthralgia (diagnostic criteria as previously described) that worsens with episodes of dyskinesia.

Examination will be positive for all of the following:

- Sensory and/or motor nerve conduction deficit
- Central and/or peripheral myopathic disease

- Muscular hyperactivity confirmed by intramuscular electromyography (EMG)
- Myalgia and/or arthralgia

Oromandibular dystonia

The *ICD-10* codes for the different types of orofacial dyskinesia are as follows:

- Acute, due to drugs: *ICD-10* G24.02
- Deformans, familial, idiopathic, and torsion dystonia: *ICD-10* G24.1

This involves excessive, involuntary, and sustained muscle contractions that may involve the face, lips, tongue, and/or jaw. They could be components of a number of central nervous systems disorders, including Parkinson disease and Meige syndrome, and could be an adverse event related to medication usage, notably neuroleptics. Trauma to the brain, head, and neck can trigger the onset of transient or permanent dystonia of the masticatory muscles. The disorder can also be genetically determined. Normally, the dystonia disappears during sleep. The affected muscles are often painful. The condition can make opening and closing the mouth difficult and impair speech, swallowing, and chewing. Sensitivity and specificity have not been established.

To allocate these diagnoses, the patient must provide a positive history of neurologic diagnosis of dystonia in the orofacial region and history components of myalgia and/or arthralgia (diagnostic criteria as previously described) that worsens with episodes of dystonia.

Examination will be positive for all of the following:

- Sensory and/or motor nerve conduction deficit
- Central and/or peripheral myopathic disease
- Dystonia confirmed by intramuscular EMG
- Myalgia and/or arthralgia

Masticatory muscle pain attributed to systemic/central disorders

Fibromyalgia (ICD-10 M79.7)

Fibromyalgia involves widespread pain with concurrent masticatory muscle pain (see chapter 10). History and examination are positive for both a rheumatologic-based diagnosis of fibromyalgia and myalgia as previously defined. Sensitivity and specificity have not been established. Historically, in diagnosing fibromyalgia, there needed to be tenderness in at least 11 of 18 specified sites and the presence of widespread pain denoted as axial pain, right and left pain, and upper and lower segment pain. Current criteria eliminate the tender points and focus on a widespread pain index and symptom severity scale.^{272,273}

Centrally mediated myalgia (ICD-10 M79.1)

Centrally mediated myalgia is defined as chronic, continuous muscle pain that is aggravated by function. Intermittent muscle pain conditions may not produce centrally mediated myalgia, while a prolonged and constant period of muscle pain is likely to lead to the condition. Sensitivity and specificity have not been established.

History must be positive for all of the following:

- Prolonged and continuous pain in the jaw, temple, in front of the ear, or in the ear in the past 30 days
- Regional dull, aching pain at rest
- Pain is aggravated by function of the affected muscles
- Presence of at least three nonspecific somatic symptoms, such as sensation of muscle stiffness, weakness, and/or fatigue
- Sensation of acute dental occlusal changes not verified clinically
- Ear symptoms (eg, tinnitus, feeling of fullness, blocked ear), vertigo, dental pain symptoms not attributed to another diag-

nosis, or headache symptoms not otherwise classifiable by the International Classification of Headache Disorders, third edition (beta version) (ICHD)

- Limited mouth opening (due to pain or myofibrotic contracture)

In addition, the examination must confirm at least two of the following:

- Myalgia
- Evidence of sensory dysfunction (eg, allodynia, paresthesia, dental occlusal awareness)
- Muscular atrophy
- Maximum unassisted opening < 40 mm including vertical incisal overlap

Headache disorders

Headache attributed to TMDs (ICHD-3 11.7; ICD-10 G44.89)

If the headache is caused by a disorder involving structures in the temporomandibular region, it can be considered a headache attributed to TMDs. According to the International Headache Society, this headache is considered present when there is evidence of a pathologic process affecting the TMJ, muscles of mastication, and/or associated structures, together with evidence of a causal relationship with the headache. Causation is demonstrated when at least two of the following symptoms are present²⁷⁴:

- Headache has developed in a temporal relationship to the onset of the TMDs.
- Headache has significantly worsened in parallel with progression of the TMDs, and/or headache has significantly improved or resolved in parallel with improvement in or resolution of the TMDs.
- Headache is produced or exacerbated by active jaw movements, passive jaw movements, and/or provocative maneu-

vers applied to temporomandibular structures such as palpation pressure.

- When unilateral, headache is ipsilateral to the side of the TMDs.

In the DC/TMD, headache attributed to TMD is included as one of the new diagnostic subtypes.²¹¹ In general, the DC/TMD criteria for this headache closely follow those of the ICHD. An important difference, however, relates to the definition of the TMD subtype that should be present: the DC/TMD specifically links the headache to a pain-related TMD diagnosis like myalgia or arthralgia. Sensitivity and specificity values are 0.89 and 0.98, respectively.

To allocate this diagnosis, both of the following criteria must be met:

- History of headaches of any type localized in the temple region during the last 30 days that are modified by jaw movement in function or parafunction
- During clinical examination, confirmation of the location of the headaches in the temporalis muscle area and report of familiar headache upon palpation of the temporalis muscle or during mandibular movements

Associated structures

Coronoid hyperplasia (ICD-10 M27.8)

Coronoid hyperplasia is progressive enlargement of the coronoid process that impedes mandibular opening when it is obstructed by the zygomatic process of the maxilla. Sensitivity and specificity have not been established.

To diagnose coronoid hyperplasia, the patient must complain of progressive limitation of jaw opening, the examination must confirm the reduction of active and passive maximum jaw opening, and imaging must show an elongated coronoid process that approximates the posterior aspect of the zygomatic process of the maxilla on opening.

Management of TMDs

Management goals for patients with TMDs are similar to those for other orthopedic or rheumatologic disorders. They include decreased pain, decreased adverse loading, restoration of function, and resumption of normal daily activities. These management goals are best achieved by a well-defined program designed to treat the physical disorder(s) and to reduce or eliminate the effects of all contributing factors. The treatment options and sequences for TMDs outlined here are consistent with treatment of other musculoskeletal disorders.

As in many musculoskeletal conditions, the signs and symptoms of TMDs over time may be transient and self-limiting, resolving without serious long-term effects.^{15,275} Little is known about which signs and symptoms will progress to more serious conditions in the natural course of TMDs. Therefore, special efforts should be made to avoid early use of aggressive, irreversible treatments such as complex occlusal therapy or surgery. Conservative (ie, reversible), noninvasive treatment such as self-management instructions, behavioral modification, physical therapy, medications, and orthopedic appliances are endorsed for the initial care of nearly all TMDs.¹⁵

Principles of management

Most patients with TMDs achieve good symptom relief with conservative therapy.^{23,276,277} Long-term follow-up of TMD patients shows that 50% to over 90% of the patients have few or no symptoms after conservative treatment; from a retrospective study of 154 patients, it was concluded that most TMD patients have minimal recurrent symptoms 7 years after treatment.²⁷⁸ More than 85% to 90% of the patients in three longitudinal studies lasting 2 to 10 years had relief of symptoms after conservative treatment.^{279–281} Stability was achieved in most cases between 6 and 12 months after the start of treatment.²⁸¹

In many patients with disc displacement (reducing and nonreducing), painless jaw function is possible with a displaced disc.^{276,282,283} Patients with pain-free clicking TMJs generally do not need treatment except for reassurance and explanation of the condition, whereas patients with nonreducing discs typically respond well to conservative treatment.^{282–285} Internal derangement of the TMJ often exhibits a natural progression of compensatory adaptation and remodeling.^{286–288} Even with progression or with osteoarthritic changes, the outcome is typically benign with adequate masticatory function.^{289,290} Myogenous disorders more frequently require recurrent treatment as compared with TMJ articular disorders.^{70,291}

Relevant precipitating and perpetuating contributing factors should be identified through the history and clinical examination. Factors such as bruxism and other parafunctional habits, trauma, adverse anatomical relationships, and pathophysiologic and psychosocial conditions may all impact TMDs, but as the majority of these factors are highly prevalent in the general population, their presence in an individual case may be coincidental and not contribute to the TMDs. Therefore, in addition to the physical diagnosis, the goal of each evaluation should be the development of a prioritized problem list of the relevant contributing factors. This has direct implications for the treatment plan and strategic sequencing.

Treatment prognosis can be affected by a number of considerations. Early treatment of acute musculoskeletal pain results in greater patient satisfaction, fewer work days lost, and reduced chance of development of a chronic pain condition.²⁹² In cases of chronic TMDs where pain is less frequent and patients engage in greater daily activity, the prognosis is better.²⁹³ The power of nonspecific effects in healing (eg, placebo effect) in the treatment of psychosocial and biologic conditions has been well documented.²⁹⁴ These effects certainly play a role in the successful treatment of TMDs, and the value of a good doctor–patient

relationship should be recognized and used.²⁹⁵ Despite the documented success of the various forms of conservative care, some patients with TMDs do not improve. Reasons for this vary, but these patients typically fall into two groups: patients with an incomplete or incorrect diagnosis or patients with unsuccessfully addressed or even unrecognized contributing factors.²⁷⁶ When multiple contributing factors are present, and especially if the condition is chronic, a pain management program with a multidisciplinary team of clinicians may be needed. It is difficult for an individual clinician to address the multiple contributing factors that may be present in complex chronic pain patients.²⁹⁶ Treatment options include patient education and self-management, cognitive behavioral therapy (CBT), pharmacotherapy, physical therapy, orthopedic appliances, occlusal therapy, and possibly surgery. It is important to also remember that Axis II (psychologic) factors need to be considered in the management of all TMDs. These factors are reviewed in chapter 12.

Patient education and self-management

The success of a self-management program depends on patient acceptance, motivation, cooperation, and compliance. The time spent on patient reassurance and education is a significant factor in developing a high level of rapport and treatment compliance. The clinician's explanation of the problem and treatment recommendations should use terminology the patient can understand.

A successful self-management program allows healing and prevents further injury to the musculoskeletal system. This may be enough to control the problem.^{23,297,298} A self-management routine should include the following: rest of the masticatory system through voluntary limitation of mandibular function, habit awareness and modification, and a home physiotherapy program. An explanation of the advantages of resting the affected

muscular and articular structures and functioning only within pain-free limits, much the same as an athlete must rest an injured joint, is often helpful. Modification of function (eg, avoidance of heavy mastication, gum chewing, wide yawning, singing, and playing certain musical instruments) and parafunctional habit reversal (eg, clenching, bruxing, tongue thrusting, cheek biting, poor sleeping posture, or object biting) should be emphasized.

Offending habits can be modified with habit awareness, motivation to change, and knowledge in how to change. Commitment to conscientious monitoring for the habits can lead to successful habit modification. A simple feedback mechanism, such as visual or audio reminders adapted to the patient's daily activities, should be discussed and implemented (eg, small stickers strategically placed at home, in the patient's vehicle, and at work; alarms sounding from electronic sources; phone apps). Keeping a diary aimed at identifying circumstances and activities that foster the offending habits may also be helpful so that the patient can titrate the need for more or less monitoring during any given day. Progress with habit modification should be discussed at each follow-up appointment with the patient.

A home physiotherapy program has also been proposed for the treatment of TMD pain and dysfunction because it is simple and non-invasive, is cost-effective, allows an easy self-management approach, cultivates good doctor-patient communication, and can be managed by the general practitioner.²⁹⁹ Emphasis should be placed on patient self-control. A program of heat and/or ice to the affected areas, massage of the affected muscles, and gentle range-of-motion exercises can decrease tenderness and pain and increase range of motion. Heat stimulates muscle relaxation and vascular perfusion. Heat should not be used following an acute injury (ie, less than 72 hours) or for acute inflammation or infection. Ice packs are used primarily for local analgesic and anti-inflammatory ef-

fects in muscle and joint tissues. Because the temperature differential is greater with cold, a shorter application may produce a greater response. Cold should not be used over areas with poor circulation (eg, as a result of diabetes or radiation) or over open wounds.

Recently, efforts were taken to construct an expert-based standardized definition of *self-management*. The core components identified for self-management include education; self-exercises; self-massage; thermal therapy; dietary advice and nutrition; and parafunctional behavior identification, monitoring, and avoidance. Self-management components can be provided to the patient first as essential interventional steps and continued as fundamental for the continuous management with the intent that these elements will be used throughout the patient's life.³⁰⁰

Biobehavioral therapy

Behavioral modification for overuse or parafunctional behaviors remains a central part of the overall treatment program for individuals with TMDs despite the as-yet unclear evidence for their overall role in etiology or in contributing to persistence of the disorder.³⁰¹ In general, the clinician should err toward overemphasis on this part of treatment based on the extent by which higher levels of parafunction are observed in individuals with chronic TMDs, the difficulty in reliably identifying the true extent of such behaviors if present except through repeated assessments over time, and the success of such treatment for those who have been refractive to conservative dental/physical medicine treatment approaches.^{52,302}

The success in reducing the frequency of parafunctional behaviors depends on several patient factors and clinical factors. Patient factors include the level and continuity of awareness of the putative behaviors, long-term motivation and commitment to treatment, and extent to which other factors (eg, life stress) are uncontrollable triggers for the behaviors.

Clinical factors include curiosity in exploring possible symptom-behavior relationships, persistence in monitoring behavioral patterns and level of patient skills, and skill in effecting behavioral change. Patients whose parafunctional behaviors may seem severe, chronic, and under the control of extensive environmental factors may nevertheless respond quickly to the clinician's initial intervention, while patients whose parafunctional behaviors seem simple may require extensive treatment from a behavioral specialist.^{301,303} Consequently, initiating intervention of parafunctional behaviors is a pragmatic decision for every patient, recognizing that significant modification of their lifestyle is often necessary to alter the contributing factors in the interest of long-term prevention of recurrent TMD pain. If a more structured approach is indicated, strategies for behavior modification such as a habit-reversal program, lifestyle counseling, CBT for stress management, progressive relaxation, hypnosis, and biofeedback should be considered. Treatment should be individualized based on the patient's problems, preferences, and lifestyle. Several manuals and texts more fully describe this information.^{304–306}

Biofeedback is a structured therapy based on the theory that when an individual receives information about a desired change and is supported in making the change, the change is more likely to occur.^{307,308} In general, biofeedback training uses equipment to measure biologic activity (eg, surface EMG to measure muscle activity). The equipment is designed with a feedback loop so that a patient can receive immediate feedback regarding performance. A number of controlled studies have demonstrated that relaxation training, with or without the use of surface EMG biofeedback, can decrease awake tonic muscle activity.^{303,309,310} Most trials evaluating biofeedback for the treatment of TMDs have been undertaken with small sample sizes, and although there is cumulative evidence of effectiveness when biofeedback was compared with con-

trols, there remains a need for large-sample, controlled-outcome trials.³¹¹

Biofeedback may be less effective in the treatment of sleep bruxism.³¹² EMG biofeedback during sleep without a more comprehensive stress management program appears to decrease sleep bruxism only temporarily, and therefore its use may be limited to short-term management of acute conditions.^{313,314} Comprehensive stress management and counseling programs that involve a combination of EMG biofeedback, progressive relaxation, and self-directed changes in lifestyle appear to be more effective when used together than any single behavioral treatment. Use of behavioral therapies in conjunction with usual physical medicine and medication therapies also appears to enhance the overall therapeutic effects.^{315,316}

A recent systematic review evaluating noninvasive interventions for persistent TMD concluded that CBT in addition to standard care yielded better results than standard care alone with regard to life interference and depression as well as pain intensity; however, the latter difference was not deemed to reach clinical importance.³¹⁷ Another recent systematic review on the effect of counseling and self-management for TMDs revealed that these strategies yielded similar positive results in pain reduction and increase in mouth opening compared with the use of interocclusal appliances with no additive effect when used together. The studies included mostly patients with myofascial pain.³¹⁸

Pharmacologic management

Pharmacologic agents may promote patient comfort and rehabilitation when used as part of a comprehensive program. Clinicians who decide to prescribe medications should be familiar with a variety of drugs to realize maximal treatment effect and benefit, avoid unexpected complications, and act in response to adverse drug interactions.

Drug misuse and abuse are of concern in the pharmacologic management of TMDs. Opioid narcotics produce tolerance and dependence and therefore are most useful in short-term, acute pain conditions. Long-term narcotic analgesic use in patients with chronic TMDs requires careful consideration.^{319–321} Prescribing drugs on a pain-contingent basis to be taken “as needed” in chronic noncancer pain has long been associated with concern that it may lead to abuse for some patients. Recent evidence, however, indicated that time-contingent prescribing of opioids may lead to use of higher amounts and may be associated with more patient concerns regarding their opioid use.³²² Given the continuing controversies and risks associated with long-term opioid use for noncancer pain, all other avenues of treatment should be pursued before relying on narcotic medication for TMD patients.

The most widely used pharmacologic agents for the management of TMDs include analgesics, nonsteroidal anti-inflammatory drugs (NSAIDs), corticosteroids, and low-dose antidepressants.³²³ Pharmacologic agents less often used include gabapentinoids, benzodiazepines, and muscle relaxants. The analgesics, corticosteroids, and benzodiazepines are indicated for acute TMD pain; NSAIDs and muscle relaxants may be used for both acute and chronic conditions; and the tricyclic antidepressants (TCAs) are primarily indicated for chronic orofacial pain management.

Analgesics

Mild analgesics (nonopiate preparations) are usually the pharmacologic agents of choice to reduce pain associated with TMDs. The non-opioid analgesics are a heterogeneous group of compounds that share certain therapeutic actions and side effects. They may be used for mild to moderate pain associated with TMDs. Aspirin, which inhibits prostaglandin synthesis, is the prototype for these compounds. All salicylate drugs are antipyretic, analgesic,

and anti-inflammatory, but there are important differences in their effects. If the patient is sensitive to aspirin, a nonacetylated aspirin, choline magnesium trisalicylate, or salsalate may be effective.³²⁴ Opioid narcotics act on specific opioid receptor sites in the central and peripheral nervous systems. Opioids have central nervous system depression qualities and addiction liabilities. They may be considered for short-term use for moderate to severe acute pain.³²⁰

Nonsteroidal anti-inflammatory drugs

NSAIDs have been reported as effective for mild to moderate inflammatory conditions and acute postoperative pain.³²⁰ A recent Cochrane review did not provide any support for or against the use of NSAIDs in TMDs.³²⁵ There are several chemically dissimilar groups of NSAIDs, which each differ in their antipyretic, analgesic, and anti-inflammatory efficacy.³²⁶ Therefore, if one NSAID fails, another agent may succeed. NSAIDs may have serious side effects, and patients on NSAIDs should therefore be carefully monitored.³²⁷ Gastrointestinal complications form the greatest risk associated with the use of NSAIDs. If gastroprotection is needed, a proton pump inhibitor should be used in conjunction with NSAID therapy. Patients who do not have cardiovascular risk and are not on aspirin therapy also may use a cyclooxygenase-2 inhibitor, if indicated, in conjunction with a proton pump inhibitor.³²⁸ Renal effects from the NSAIDs can also cause or increase hypertension as well as lead to acute renal injury.³²⁹ All NSAIDs contain the same box warning regarding cardiovascular and gastrointestinal toxicity regardless of the route of administration. NSAIDs increase risk of serious and potentially fatal cardiovascular thrombotic events including myocardial infarction and stroke; risk may occur early in treatment and may increase with the duration of use. NSAIDs are contraindicated for coronary artery bypass graft pain management.³³⁰

Corticosteroids and sodium hyaluronate

Corticosteroids are potent anti-inflammatory drugs not commonly prescribed for systemic use in the treatment of TMDs due to their side effects. The exception is for acute severely painful joint inflammation, or joint inflammation associated with the polyarthritides. Intra-capsular TMJ injection of corticosteroids (ie, methylprednisolone) has been recommended on a limited basis in cases of acute flare-up of severe joint pain where conservative treatment has been unsuccessful. Although there have been some concerns regarding long-term effects (ie, progression of joint destruction), the 6-month follow-up appears good for alleviating TMJ pain and dysfunction with no or minimal increase of radiographically visible degenerative changes.^{331,332}

Sodium hyaluronate is the sodium salt of purified natural sodium hyaluronic acid. Hyaluronic acid is a naturally occurring polysaccharide belonging to the glycosaminoglycan family. In healthy synovial joints, hyaluronic acid maintains viscosity of the synovial fluid and supports the lubricating and shock-absorbing properties of the articular cartilage. Currently, hyaluronate has not demonstrated a superior result to other treatments, and a review on the use of hyaluronate for TMDs could not support or refute its use.^{333,334} RCTs are needed to provide evidence of efficacy of hyaluronate over standard treatments for TMDs.

There are limited studies on injecting platelet-rich plasma (PRP) in intra-articular TMDs. One study comparing PRP to arthrocentesis in patients with anterior displaced discs with reduction demonstrated a better response with PRP.³³⁵ Larger controlled studies are needed to demonstrate effectiveness, along with long-term follow-up and cost-analysis comparisons.

Benzodiazepines

Benzodiazepines are antianxiety agents that have been administered to patients with chronic pain. These drugs are potentially habit forming, and there is a concern that they may worsen depression in chronic pain patients.³²³ A review of studies could not support or refute their use.^{325,336}

Muscle relaxants

Muscle relaxants that are used to reduce skeletal muscle tone are prescribed in an effort to reduce the supposed increased muscle activity associated with TMDs.³³⁷ Experimentally, muscle relaxants depress spinal polysynaptic reflexes preferentially over monosynaptic reflexes. Muscle relaxants affect neuronal activity associated with muscle stretch reflexes, primarily in the lateral reticular area of the brainstem. The oral doses of all of these drugs are well below the levels required to elicit experimental muscle relaxant activity. Therefore, some investigators conclude that their muscle relaxant activity is related only to their sedative effect.³²³ Some central skeletal muscle relaxants are available in combination with analgesics.

In TMD patients, cyclobenzaprine was found to be statistically superior to either placebo or clonazepam in reducing jaw pain upon awakening, but neither drug had any effect on sleep improvement.³³⁸ Another study reported no difference in efficacy between short-term treatment of TMD patients with a splint or with orphenadrine.³³⁹ Recently, a combined protocol utilizing splint therapy with either a placebo or combined muscle relaxant and benzodiazepine demonstrated better pain control with the active medications.³⁴⁰ As with other pharmacologic treatments, additional RCTs are needed prior to determining if muscle relaxants are of benefit in treating TMDs. Because there is limited evidence of efficacy of muscle relaxants in the treatment of TMDs, their use should probably be limited to a brief trial in conjunction with conservative TMD therapy.

Antidepressants

Antidepressants have been used in chronic pain and have demonstrated pain relief that is not associated with depression relief.³⁴¹ The TCAs, particularly amitriptyline, have analgesic properties independent of antidepressant effect and are prescribed for chronic pain patients with depression and sleep disturbance.³⁴² The therapeutic effect of these drugs is thought to be related to their ability to increase the availability of the biogenic amines serotonin and norepinephrine at the synaptic junction in the central nervous system. The TCAs are beneficial in dosages as low as 10 mg in the treatment of tension-type headache and musculoskeletal pain.³⁴³ They decrease the number of awakenings, increase slow-wave sleep (δ sleep), and markedly decrease time in rapid eye movement (REM) sleep. For these reasons, it was thought that TCAs might have potential in the treatment of certain types of sleep bruxism; however, three double-blind crossover studies reported that amitriptyline did not significantly decrease EMG activity or pain levels but did decrease stress levels associated with sleep bruxism.^{344,345} Similarly, a systematic review on the use of TCAs in the treatment of TMDs indicated inconsistent or limited quality patient-oriented evidence for the use of this intervention.³⁴⁶ Amitriptyline has been reported, however, to significantly reduce pain associated with both chronic muscular and TMJ dysfunction, and in combination with CBT showed significant improvement over placebo.^{347,348} The therapeutic doses required to achieve an antidepressant action are significantly larger than those needed to achieve pain control and sleep improvement, and treatment of depression with these medications should only be performed by clinicians who are trained in the diagnosis and treatment of depression.

Most recently, the effect of selective serotonin reuptake inhibitors (SSRIs), selective serotonin-noradrenaline reuptake

inhibitors (SSNRIs), and TCAs on pain was evaluated.³⁴⁹ In this meta-analysis, limited to placebo-controlled trials with an intervention period up to 6 months on a primary depressive disorder population, pain relief was significantly superior in the SSRI and SSNRI groups compared with placebo, but there was no difference between these two drugs. Using a limited number of trials, no significant results were observed with the use of TCAs compared with placebo. Secondary analysis included non-placebo-controlled trials with TCAs showing a trend of improvement but not better than SSRIs and SSNRIs; both analyses with TCAs should be interpreted with caution and are not conclusive. More so, it is important to keep in mind that the transfer of these results to a primary pain population is limited. In a qualitative analysis on the effect of SSRIs in various chronic pain conditions (not specific to TMD), the authors concluded that SSRIs seem to have a positive effect in 70% of the trials.³⁵⁰ In a Cochrane systematic review, no beneficial effect was found with the use of SSRIs and SNRIs on the prevention of tension type headaches.³⁵¹ Patients with TMDs are more likely to already be on an antidepressive agent and thus may not be candidates for treatment with these agents.³⁵²

Gabapentinoids

A well-designed RCT evaluated the effectiveness of gabapentin on the treatment of chronic pain in the masticatory muscles.³⁵³ The authors concluded that this agent was clinically and statistically superior to placebo in reducing pain and hyperalgesia and improving daily function. As of this printing, however, this result has not been replicated by other investigators. Most of the trials using this agent focus on neuropathic pain conditions (postherpetic or diabetic) for which pregabalin is cleared by the US Food and Drug Administration (FDA). Gabapentin is FDA-cleared for postherpetic neuralgia.

Glucosamine and chondroitin

These nutritional supplements have gained widespread use in the treatment of osteoarthritis with the potential theory that they act as disease-modifying agents not only to reduce the symptoms but also to modify the natural history of osteoarthritis. Although a positive effect with their use has been shown, there are few high-quality trials, specifically in the progression of the disease.³⁵⁴ In a recent report from a multicenter RCT using these supplements in a knee osteoarthritis model, it was demonstrated that the combination has comparable efficacy to celecoxib in reducing pain and stiffness and increasing function after 3 months, but such effects do not increase at the 6-month follow-up.³⁵⁵

The effects of glucosamine hydrochloride (GH) and chondroitin sulfate (CS) have been evaluated in specific TMD populations, first in a pilot study using 1,200 mg of chondroitin and 1,500 mg of glucosamine for 12 weeks. It was reported that participants using GH-CS had improvement in pain, TMJ tenderness, and joint sounds compared with over-the-counter medication use.³⁵⁶ In one study, glucosamine sulfate (GS) had a significantly greater decrease in TMJ pain with function compared with ibuprofen, while in another study comparing it with a placebo, GS seemed to have no superior effect in reducing signs and symptoms of osteoarthritis in the TMJ.^{357,358}

Topical medications

Topical NSAIDs are approved to treat osteoarthritis pain (diclofenac formulations), and it is suggested that this formulation has similar effectiveness to oral formulations but with a greater safety profile due to lower serum concentrations.³³⁰ Other formulations have been investigated (eg, ibuprofen, ketoprofen, piroxicam, and indomethacin), and it has been strongly suggested to consider the use of topical diclofenac and ibuprofen in the treatment of acute soft tissue injuries

or chronic joint-pain-related conditions.³⁵⁹ A 2012 systematic review failed to show sufficient evidence to support the use of topically applied NSAIDs in painful DJD of the TMJ.³⁶⁰ Topical capsaicin has not been shown to be effective when compared with placebo in the TMD patient.³⁶¹ Transdermal patches could be evaluated for TMD, but the practicality would be limited.

Other considerations

In a Cochrane systematic review in which only trials comparing the active intervention versus placebo were included, there was insufficient evidence to either support or refute the use of NSAIDs, benzodiazepines, anticonvulsants, muscle relaxants, propanolol, oral GH-CS, and topical capsaicin in the treatment of chronic TMDs.³²⁵ All presented pharmacologic agents have in theory a biologic plausibility, but in general, in the field of TMD as a chronic pain condition, the efficacy and safety of most of them lack evidence due to methodologically compromised data.

Several other supplements used in pain management have also been suggested for the treatment of primary headaches and osteoarthritis. However, there is a lack of evidence to support their use as primary therapies; and therefore, they are mainly suggested as adjuvants. It has been suggested that magnesium provides an analgesic effect in postoperative pain and chronic neuropathic pain as well as increased opioid analgesia, but most of the available data were based on animal studies.^{362,363} However, clinical studies have indicated that magnesium supplementation reduces opioid consumption. Vitamins C, D, and E have also been evaluated in the management of pain. Vitamin C exhibits analgesic properties, which may reduce pain and increase quality of life, and has been studied mainly in orthopedic populations.³⁶⁴ Existing literature does not support vitamin D supplementation as an efficacious independent treatment for pain management.³⁶⁵ However, it has been suggested that vitamin E

plays a role in decreasing the reactive remodeling in osteoarthritis.³⁶⁶ Nevertheless, no data are specifically available for the management of TMDs with these supplements.

Physical therapy

Physical therapy helps to relieve musculoskeletal pain and to restore normal function by altering sensory input; increasing range of motion; reducing inflammation; decreasing, coordinating, and strengthening muscle activity; and promoting the repair and regeneration of tissues. In most cases, physical therapy is used as an adjunct to other treatments. Systematic reviews have demonstrated that some physical therapy modalities have support in decreasing pain and increasing range of motion of the jaw.^{367,368} However, more recent RCTs report that the long-term decrease in pain and improvement in function in patients with masticatory muscle pain or disc displacement without reduction could not be attributed to physical therapy.^{369,370} Particularly, the effect of *manual therapy*, defined as “any hands-on therapy,” seems to improve pain, mandibular motion, and pressure pain threshold.³⁷¹ This is further evidenced by meta-analysis methodology, which demonstrated that physiotherapy leads to pain reduction and may improve range of motion.³⁷²

Posture training

The goal of posture training involves the prevention of untoward muscle activity of the head, neck, and shoulder musculature, as well as the masticatory and tongue muscles. The aim should be to maintain orthostatic posture to prevent increased cervical and shoulder muscle activity and possible protrusion of the mandible. The more anterior the head is relative to the spinal column, the greater is its effective weight. Except during function (ie, chewing, swallowing, and speaking), the mandible should be in a relaxed rest position with the teeth separated.³⁷³

RCTs of posture training are supportive of utilizing this technique in patients with TMDs.³⁶⁸ Although posture training is a common physical therapeutic approach, its relationship to TMDs is not well understood and needs further study.³⁷⁴ A common reversible treatment approach aiming to modify awake parafunctional activity is to monitor and control tongue position, mimicking rest position and reducing muscle activity in principle; nevertheless, available information is controversial because position of the tongue on the floor of the mouth minimizes muscle activity or has no effect.^{373,375,376}

Exercise

Clinical experience suggests that an active exercise program is important to the development and maintenance of normal muscle and joint comfort, function, and stability. One of the objectives of an exercise program is to teach the patient how to avoid activities that are injurious to the involved synovial joints. In addition, exercise has been recommended to stretch and relax the cervical and masticatory muscles, mobilize and stabilize the TMJs, increase muscle strength, and develop normal coordination arthrokinematics (reduce joint clicking).³⁶⁸ Three types of exercise are generally recommended: repetitive exercises to establish coordinated, rhythmic muscle function; isotonic exercises to increase range of motion; and isometric exercises to increase muscular strength. These exercises are prescribed to achieve specific goals and are modified as the patient progresses. Most patients will not exercise if it increases pain. Therefore, the therapist must initially help the patient achieve some symptom relief with physical agents or modalities. A maintenance level of exercise is recommended to ensure long-term resolution once the patient has reached the goals of treatment. A recent systematic review and meta-analysis showed that most of the effect sizes for this type of intervention were low to moderate with no clear discrimination

of exercises in comparison to other conservative treatments.³⁷⁷

Mobilization

Mobilization techniques are indicated for improving decreased range of motion and pain due to muscle contracture, disc displacement without reduction, and fibrous adhesions in the joint. In some cases, repeated manipulation by the therapist can restore a more physiologic resting muscle length or improve joint function to allow a normal range of jaw motion.²²⁰ Muscle relaxation and pain reduction are often required to enhance the effect of mobilization. Thus, a combination of heat, cold, ultrasound, and electric stimulation is often employed before or in conjunction with mobilization. Acute disc displacement without reduction can at times be effectively reduced by manipulation of the mandible.³⁷⁸ The mobilization may be accomplished through gripping the mandible firmly with the thumbs on the occlusal surfaces of the posterior teeth. The unaffected side is securely braced, and firm but controlled force is applied to the mandible in a downward, forward, and inward direction.^{1,379} Another technique incorporates the patient's voluntary maximal lateral excursive jaw movement to the unaffected side followed by opening through the lateral border path.^{379,380} Following mobilization, therapy to maintain joint mobility should be considered, such as orthopedic appliance therapy, relaxation therapy, and exercises.

Physical agents or modalities

Physical agents or modalities used for TMD management include electrotherapy, ultrasound, iontophoresis, anesthetic agents, dry needling (ie, botulinum toxin), acupuncture, and low-level laser therapy.

Electrotherapy

Electrotherapy devices can produce thermal, histochemical, and physiologic changes in the muscles and joints. These devices include

electrogalvanic stimulation (EGS), transcutaneous electrical nerve stimulation (TENS), and microvoltage stimulation. EGS uses a high-voltage, low-amperage, monophasic current of varied frequency. This modality has been applied clinically in an effort to aid in muscle relaxation, reduce inflammation, and increase blood flow to tissues.³⁶⁸ TENS uses a low-voltage, low-amperage, biphasic current of varied frequency and is designed primarily for sensory counterstimulation in painful disorders.³⁸¹ Like EGS, this modality decreases muscle pain and hyperactivity and can aid in muscle reeducation. If significant motor stimulation occurs concurrently, this may impair the analgesic effect and exacerbate acute muscle pain.³⁸² Although TENS has more traditionally been used outside of the temporomandibular area, application techniques for temporomandibular and cervical pain have been described. A review of TENS in 1997 gave equivocal results with a possible short-term benefit but no difference in outcomes over time.³⁸³

Ultrasound

Ultrasound is a frequently used physical treatment modality for musculoskeletal problems. The high-frequency oscillations of the transducer head are converted to heat when transmitted through the tissue. This can heat the tissues to a depth of 5 cm.³⁸⁴ It has been proposed that ultrasound may be used to produce deep heat in the joints; treat joint contracture by increasing the stretch of the extracapsular soft tissue; decrease chronic pain, muscle contraction, and tendonitis; and facilitate resorption of the calcium deposits of bursitis.^{384–386} Ultrasound is also commonly used to carry medication into the tissue through phonophoresis, although the mechanism and efficacy of drug delivery are unknown.³⁸⁷ A systematic review on the efficacy of ultrasound on the musculoskeletal system revealed that only 2 of 18 placebo-controlled trials showed a statistically and clinically significant benefit of ultrasound. The four trials related to TMDs did not

reach the quality standard used in the review. In addition, they did not show any significant benefit of ultrasound.³⁸⁸

Iontophoresis

Iontophoresis is a technique to enhance the transport of drug ions across a tissue barrier. A weak current is used to enhance the transport of drug ions—usually corticosteroids—through the skin into the deeper tissues, where the drug is purported to exert its effect.³⁸⁹ However, RCTs have not supported the efficacy of this modality to provide pain relief.^{390,391}

Anesthetic agents

Anesthetic agents have been proposed to be beneficial to TMD therapy. Application of vapocoolant sprays followed by muscle stretching decreases muscle soreness and tightness and is thought to inactivate myofascial trigger points (TPs).^{66,392} To date, there are no RCTs showing efficacy of such therapy.

Local anesthetic injection of myofascial TPs, alone or in conjunction with muscle stretching or mobilization, has been shown to be useful for the management of myofascial pain. Although the anesthetic is useful in pain reduction, it is not the most critical factor in eliminating pain.^{393–395} Rather, it appears that the mechanical disruption of the TP by the needle provides the therapeutic effect. TP injections should be used adjunctively with other modalities such as pharmacotherapy, physical therapy, and—in many cases—behavioral medicine techniques.³⁹⁶ TP injections are usually performed in a series of three to five treatments to an individual muscle group, initially at weekly intervals. Long-acting local anesthetics such as bupivacaine should not be used for muscle injections because of increased myotoxicity, and there is no need to incorporate a vasoconstrictor because the integrated TP physiologic model suggests a localized hypoxic energy associated with sensory and autonomic reflexes.^{397,398} In a recent RCT, the effect of TP injections infiltrating with

either saline or anesthetic showed no differences in pain intensity, headache frequency, or intensity between the two intervention groups. It is important to note that the interventions were enhanced with muscle stretching, anti-inflammatory medications, and thermal therapy.³⁹⁹

Botulinum toxin

Botulinum toxin has been trialed in the treatment of myofascial TPs. In a recent review of the literature, it was concluded that there was insufficient evidence to determine whether or not this medication is effective due to the lack of an adequate number and poor quality of the clinical trials.⁴⁰⁰ An update of a Cochrane review did not find new studies and concluded that there is insufficient evidence for botulinum use, highlighting that there is a lot of heterogeneity between the studies, including lack of standardized outcome measurements, treatment modalities, and follow-up.⁴⁰¹ Contrasting results in a more recent systematic review and meta-analysis including only double-blind studies with placebo controls showed that pain intensity was significantly reduced in the botulinum-A groups compared with placebo groups at a relatively long term of 6 months, although the cost-effectiveness is questioned.⁴⁰²

Acupuncture

Acupuncture has also been used for the treatment of chronic musculoskeletal pain, but the precise mechanism of action is unknown. Early studies of its application for TMDs suggest that the benefits of acupuncture are comparable with conventional TMD treatments.²⁹³ However, a systematic review and meta-analysis of acupuncture demonstrated only limited evidence that acupuncture treatment in TMDs is more effective than sham acupuncture, while others support that conventional acupuncture is effective.^{403,404} These contrasting findings suggest that there is a need for rigorous clinical trials evaluating

acupuncture as an adjunctive therapy before definitive recommendations regarding its application can be made.

Low-level laser therapy

Low-level laser therapy has been used for the treatment of TMDs and is suggested to have biostimulating and analgesic effects through direct irradiation without causing a thermal response.⁴⁰⁵ Consistent findings support the claim that low-level laser therapy was no better than placebo in reducing chronic TMD pain.^{406,407} Because of the poor methodologic design of the studies and the utilization of different types, frequencies, and duration of laser radiation in various patients groups, treatment parameters have not been standardized, and effectiveness cannot be evaluated. Two RCTs published just subsequently to the systematic review time period demonstrated positive effects of the laser therapy compared with controls and positive but equal effects to splint therapy.^{408,409} Because of the small sample size of these studies, further research is needed to support the use of low-level laser therapy in TMD treatment.

Orthopedic appliance therapy

Orthopedic appliances, including interocclusal splints, orthotics, orthoses, bite guards, bite planes, night guards, or bruxism appliances, are routinely used in the treatment of TMDs. Based on current theory, removable acrylic resin appliances that cover the teeth have traditionally been used to alter occlusal relationships and to redistribute occlusal forces, to prevent wear and mobility of the teeth, to reduce bruxism and parafunction, to treat masticatory muscle pain and dysfunction, to treat painful TMJs, and to alter structural relationships in the TMJ.⁴¹⁰ Researchers have not agreed, however, on the mechanism of action, what the most effective occlusal design is, or even whether the appliances are more effective than placebos or other treatments.^{411–415}

Generally, studies focusing on appliance therapy have reported a reduction in orofacial pain and other symptoms associated with TMDs.^{315,411,416–418} However, most studies have been limited by small sample size, short-term outcome, inadequate control groups, and failure to compare appliance therapy with other forms of treatment. Furthermore, several review papers have concluded that when these appliances were compared with an inactive placebo, they were mildly favorable, performing no better than nonoccluding appliances or other types of TMD therapies such as behavioral modification or self-regulation strategies.^{415,419–424} The most recent systematic reviews and meta-analysis, however, did conclude that there is a moderate effect for reduction of pain with the use of splint therapy in TMDs.^{407,425} The three types of orthopedic appliances that are described here include full-coverage stabilizing appliances, partial-coverage appliances, and anterior positioning appliances.

The complications that can occur with the excessive or incorrect use of any appliance include caries, gingival inflammation, mouth odors, speech difficulties, occlusal changes, and psychologic dependence on the appliance. Serious complications can include major, irreversible changes in functional and morphologic occlusal features as a result of long-term, full-time use of these appliances.^{426,427} This is a significant concern with partial-arch coverage appliances.

Stabilization appliances

Stabilization appliances cover all of the maxillary or mandibular teeth. Stabilization appliances are used as an adjunct for managing symptoms associated with myogenous as well as arthrogenous TMDs.^{315,428–431} Preferably, they are used during sleep only, whereas behavioral modification strategies may be used to increase the patient's awareness and reduce the impact of parafunctional habits on TMDs while awake. Because acrylic is softer than enamel,

these appliances have been used to reduce the chance of further tooth attrition in patients with sleep bruxism. Stabilization appliances can also be used for the management of an unstable occlusion, such as missing multiple bilateral posterior tooth contacts. Occasionally, they are used to reduce clenching-induced earache and tooth pain as well as some forms of temporal headache.^{432–436}

EMG monitoring of the masseter muscle has been used in an attempt to demonstrate a short-term decrease in the level of sleep bruxism activity when an appliance is worn.^{437,438} However, studies demonstrated that the response is variable and that sleep bruxism is not eliminated with stabilization appliances.^{88,410,439} These studies emphasize the variability of the clinical response to these appliances and the need for careful follow-up. The occlusal surface of the appliance should be adjusted to provide a stable physiologic mandibular posture by creating bilateral, even posterior occlusal contacts for the opposing teeth on closure.⁸⁸ Appliances adjusted to a “neuromuscularly determined” jaw position seem to show no advantage over conventional stabilization appliances.¹⁹³ Anterior guidance may be provided by acrylic guide ramps in the canine or anterior areas of the appliance to separate the opposing posterior teeth from the appliance in all excursive movements of the mandible. Clinical experience suggests that the occlusal surface of the appliance should be adjusted initially and periodically to compensate for changes in the maxillomandibular relationship as pain, muscle activity, inflammation, edema, or soft tissue structural relations change.

In acute cases, the appliance may be worn full-time for a specified period of time. As symptom reduction occurs, use of the appliance only during sleep is preferred. This is especially true with ongoing sleep bruxism and related morning pain. Patients not showing a positive response within 3 to 4 weeks should be reevaluated. Failure to show an initial positive response does not necessarily indicate a

need for more aggressive or prolonged therapy; other factors should be considered such as chronic pain behavior, noncompliance, misdiagnosis, or degree of TMJ pathology.

Use of a stabilization appliance with adjunctive therapy for pain relief and improved function is also a viable treatment option for TMJ internal derangement.^{440–442} Asymptomatic clicks by themselves do not warrant treatment, and studies using TMJ imaging throw doubt on the need for a “correct” or “perfect” disc position.⁴⁴³ In the treatment of internal derangement, if improvement is not realized with orthopedic appliance therapy and adjunctive measures, and if significant pain and mechanical symptoms persist, minimally invasive procedures such as arthrocentesis and/or arthroscopy or open joint surgery may be necessary.

Past research regarding the use of stabilization appliances fabricated with a soft resilient material have provided mixed results regarding the effect of these appliances in reducing sleep bruxism and signs and symptoms of TMDs.^{437,444–447} Concern regarding the effect of using unadjusted appliances on occlusal contacts has been raised.⁴⁴⁸ One study suggested that the efficacy of these appliances may be related to the stability of the appliance occlusion, and with stable contacts, occlusal changes do not occur.²⁹⁸ Studies comparing soft appliances with hard acrylic appliances have found both to be equally effective in reducing painful symptoms, but they were no more effective than self-management treatment without appliance therapy.^{446,447} Techniques for adjusting soft resilient appliances are available.^{379,449} These appliances currently seem best suited for treatment of children with a mixed dentition as the soft appliance seems to have minimal effect on dental development.⁴⁴⁴

Partial-coverage appliances

One type of partial-coverage appliance only covers the maxillary central incisors and contacts with only one or two opposing mandibular teeth.⁴⁵⁰ The claimed mechanism of action

was that occlusal forces applied to a few anterior teeth would be less than forces applied to a full occlusion, resulting in a decrease in muscle activity and/or diminished loading of the TMJ. Whereas in a 3-month follow-up study, no differences in improvement were observed between TMD patients wearing this appliance and patients wearing a stabilization appliance, a 6-month follow-up study reported that more patients in the stabilization appliance group improved.^{451,452} A systematic review of this type of appliance indicated that they can be used successfully, but they should only be used in cases where patients will be compliant with their follow-up appointments.⁴⁵³ Due to its compact size, a less than well-retained appliance at night has the potential risk for aspiration. Recently, it was reported that the use of this type of device as initial therapy did not provide any additional benefit in reducing pain or improving jaw function.⁴⁵⁴

Another partial-coverage oral appliance is one that covers only the posterior teeth. The posterior bite plane is usually fabricated for the mandibular teeth and consists of areas of hard acrylic located over the posterior teeth and connected by a cast metal lingual bar. It has been advocated in cases of loss of vertical dimension or when there is a need to make major changes in anterior positioning of the mandible.⁴⁵⁵ The efficacy of this type of appliance has been studied in only one small controlled trial.⁴⁵⁶

Studies supporting the efficacy of partial-coverage appliances in reducing TMD symptoms are limited by number and sample size. In addition, they have the potential to produce a malocclusion and possible internal TMJ changes.⁴⁵² There is no evidence to state that they reduce TMD symptoms more effectively than full-arch appliances.

Anterior positioning appliances

Anterior positioning appliances, also called *anterior repositioning appliances*, are usually fabricated for the maxillary arch to guide the mandible into a protrusive position. All teeth in

the arch are covered, and the opposing teeth are provided with minimal posterior occlusal indentations and a reverse guidance incline in the anterior segment of the appliance.⁴⁵⁷ This design is aimed at providing guidance to a more comfortable therapeutic condyle-disc-fossa relationship. Anterior positioning appliances are used to decrease joint pain, joint noise (clicking), and associated secondary muscle symptoms in TMDs.^{458,459} The primary indication for anterior positioning appliance therapy is acute joint pain associated with disc displacement with reduction.^{315,460,461} Originally, full-time use of the appliance was suggested with the intent to establish a new jaw position with the disc "recaptured."⁴⁶² Although short-term success with full-time wear of anterior positioning appliances was good, long-term success at establishing a new occlusal position with the disc recaptured has not been realized.^{26,459,460,463–465}

Therefore, attempts to achieve a new therapeutic mandibular position aimed at restoring the disc-condyle relationship with anterior positioning appliances should be restricted to a few select cases of articular pain that can only be managed by maintained jaw positioning. In these cases, the patient needs to understand in advance the involved nature of the treatment in terms of time and expense. Whether the appliance will be used full-time or part-time, the potential occlusal consequences need to be discussed with the patient prior to treatment since mandibular repositioning can result in irreversible changes in the occlusion (ie, a posterior open bite).⁴⁶⁶

An anterior positioning appliance may be effective in reducing symptoms associated with disc displacement with reduction. Use of the appliance during sleep is also often effective for preventing intermittent disc displacement without reduction on awakening and reducing joint pain. By using the appliance only during sleep, the potential for occlusal changes is greatly reduced. Full-time short-term wear of the anterior repositioning appliance should be limited to cases with acute disc displace-

ment without reduction (ie, acute closed lock), only if the clinician is able to reduce the disc (ie, unlock the jaw). In such cases, restoring the disc-condyle relationship full-time for 5 to 7 days may reduce or prevent additional locking episodes and encourage adaptation. Once joint pain and dysfunction are decreased, the appliance use may be gradually reduced to sleep-time wear only, and, if needed, eventually replaced with a stabilization appliance.

The goal of this treatment is to allow the mandible to approximate the pretreatment occlusal position, as ample evidence has determined that permanent mandibular repositioning as a treatment goal for TMDs does not fall within the standard of medically necessary treatment.⁴⁶⁷ This approach is strongly recommended to avoid or minimize the need for unnecessary restorative or orthodontic treatment. The treatment is not intended to correct the disc-condyle relationship but to facilitate control of symptoms similar to other treatments.²⁸² Clicking is not usually eliminated but may be decreased in intensity. In some instances, returning the patient to the preexisting occlusal condition reinitiates the painful joint symptoms. This is likely due to the lack of adaptation of the retrodiscal tissues. In most instances, immediately returning the patient to the anterior positioning appliance therapy will once again reduce the symptoms. When this occurs, more time should be allowed for tissue adaptation. Allowing more time will minimize the need for any permanent occlusal changes. Only after repeated unsuccessful attempts to return the joint to an orthopedically stable position in the fossa should permanent occlusal changes be considered. The need for permanent occlusal therapy is very rare and should not be considered a goal of therapy, but rather necessary due to the potential risks associated with long-term use of repositioning appliances.

Occlusal therapy

Those interested in studying TMD pathophysiology and therapeutic concepts related to occlusal discrepancies may struggle with the role of occlusion in TMD treatment. It is difficult to establish any significant cause and effect relationships due to the many variables involved with these multifactorial problems.^{115,468,469} Many of these variables are difficult if not impossible to exclude clinically. There are valid reasons for occlusal treatment for many dental conditions: lack of inter/intra-arch tooth stability; tooth mobility; fremitus; occlusal-related fracture of a tooth or restoration; tooth sensitivity; altered or compromised masticatory function, swallowing, or speech; and compromised supporting tissues due to adverse loading. Although occlusal-related dental treatment may be necessary for patients with TMDs, it is believed to be unnecessary for the purpose of treating TMDs.³³⁶

The use of anterior positioning appliances in the treatment of TMJ disc displacement to establish a mandibular position with a corrected disc-condyle relationship has led to the concept of two-phase treatment. This treatment approach was especially popular in the late 1970s and the 1980s. Phase 1 involved the use of the anterior positioning appliance and any adjunctive therapies. Phase 2 involved rearticulation of the teeth in the newly acquired therapeutic jaw position through definitive, irreversible occlusal treatment: occlusal adjustment, restorative or prosthodontic dental treatment, or orthodontic or orthognathic treatment. Given that permanent mandibular repositioning as a treatment goal does not fulfill all of the criteria for medical necessity, it is strongly suggested that the use of the terms *phase 1* and *phase 2* treatment of TMDs be discontinued.⁴⁶⁷ The problem with this terminology is that it implies that phase 2 treatment inevitably follows phase 1 treatment. The scientific literature does not support the need for a two-phase treatment because definitive

occlusal therapy is not required for the effective treatment of most TMDs.^{470,471} In spite of the lack of scientific support, the two-phase philosophy continues to be promoted by many continuing education courses and concepts of occlusal etiology for TMDs and is adhered to by many dental professionals.⁴⁷²

Primary occlusal therapy should be used with caution because there is no evidence that natural occlusal morphologic variation is a common cause of TMDs.^{115,184,470,473,474} Based on current evidence, the routine emphasis of treatment of chronic malocclusions to treat TMDs is unsupported. TMDs, especially involving TMJ pathology, may affect the dental occlusion. In other words, the malocclusion may be a consequence of the TMDs rather than a cause.^{475,476} The clinician should not proceed with occlusal treatment to correct the resultant malocclusion until he or she is reasonably assured that the TMJ pathology is stable and no further changes are likely. Evidence of stability may be obtained through longitudinal monitoring of pain symptoms, occlusal relationships, TMJ imaging, and cephalometric measurements. The risk of recurrence or progression should be clearly communicated to the patient before initiating the definitive occlusal treatment.

The clinician is advised to proceed cautiously, using the least invasive procedures possible, when treating occlusal changes in the TMD patient.⁴⁷⁷ The pretreatment intercuspal relationship should be preserved whenever possible. There is no evidence that anterior guidance is superior to other forms of guidance for treating TMD symptoms related to sleep bruxism.^{478,479} Also, anterior guidance may not provide optimal joint loading for all TMD articular conditions.^{161,480} Thus, altering the occlusion to provide anterior guidance for patients with TMDs is questionable. In general, there is a lack of evidence that complex occlusal therapy to provide an idealized dental occlusion is necessary for routine TMD management.^{470,474,481}

Occlusal adjustment

Occlusal adjustment was at one time considered beneficial for TMDs, and occlusal interferences were implicated in the etiology of TMDs. However, there is no evidence for which type of occlusal interference, if any, might impede jaw function or play an etiologic role in the development of TMDs.⁴⁷⁰ A review of studies adding artificial occlusal interferences failed to induce TMD symptoms and in fact showed reduced masseter activity after application of the occlusal interference.^{470,482} A Cochrane Database review and several other systematic reviews of RCTs showed that there was not enough evidence that occlusal adjustments are useful to prevent or treat TMDs.^{423,470,483,484} For these reasons and because occlusal adjustment is an irreversible and invasive treatment modality, it should not be considered as initial therapy for TMDs. The reviews agree that occlusal adjustment may be considered as a treatment option to improve mandibular stability in cases where specific TMD disturbances have resulted in an unstable occlusal relationship, or when an occlusal interference related to a recently placed restoration precipitates symptoms.

Restorative and prosthodontic therapy

Restorative or prosthodontic dental care should never be a primary treatment option for TMDs.⁴⁷⁰ Once stability and symptom resolution are achieved, restorative therapy has been suggested for patients who might likely benefit from reduction of adverse loading and redistribution of occlusal forces, as suggested by earlier studies.^{485–487} However, as with other irreversible and invasive occlusal therapies like occlusal adjustment, the efficacy of this treatment for TMDs is not predictable, and further research is needed on the influence of dental occlusion on TMJ loading. There are a few instances when the occlusal condition is associated with TMD symptoms by way of functional mandibular instability. In these instances, the

occlusal condition must be addressed, but any extensive restorative therapy in TMD patients should be undertaken with caution. Sudden, radical changes in occlusion in these patients carry some risk, though the occlusal alterations are usually well tolerated according to human and animal studies.^{488–490}

Orthodontic-orthognathic therapy

Orthodontic treatment is often the treatment of choice when major occlusal alterations are considered to be dentally advantageous. Fixed, removable, functional, and extraoral orthodontic appliances are all capable of improving occlusal and mandibular stability.⁴⁹¹ Orthodontics has been suggested subsequent to anterior positioning appliance therapy to correct a TMJ disc displacement. This has not proven to be as successful on a longitudinal basis as anterior positioning appliance therapy alone.^{492,493} Orthodontic therapy does present some risk of destabilizing the masticatory system during treatment.⁴⁹⁴ Therefore, the orthodontic diagnosis and treatment plan must consider possible influences of resulting occlusal instability during treatment on preexisting TMDs.^{495,496}

Many retrospective clinical studies have examined the relationship between orthodontic treatment and TMDs and have found no significant correlation on a population basis.⁴⁹⁷ Additionally, several recent prospective long-term studies also confirm no correlation between orthodontic treatment in childhood and increased risk of developing TMDs later in life.^{433,498–500} Orthodontic treatment with premolar extraction has been specifically implicated in the development of TMDs through incisor retraction and subsequent distalization of the mandible.⁵⁰¹ However, studies comparing orthodontic treatments with and without premolar extraction have found no difference in posttreatment condylar position, overbite, discrepancy between ICP and RCP, or symptoms of TMDs.^{502–507} In a prospective study of posttreatment changes in the TMJ, no statistically significant correlation between changes

in the condyle/fossa relationship based on age, sex, skeletal or dental variables, signs or symptoms of a TMD, headgear use, type of elastics, or nonextraction vs extraction treatment were identified.⁵⁰⁸ Additionally, there are some longitudinal studies that suggest patients with a history of orthodontics tend to have a lower prevalence of signs and symptoms than those with no history of orthodontic treatment.^{433,509}

A review of the literature concluded that, based on the available evidence, orthodontic treatment “neither causes nor cures TMDs.”⁵¹⁰

Although there is little evidence that orthodontically treated patients as a group have a greater prevalence of TMD symptoms, the individual patient response to the dental instabilities associated with orthodontic treatment may be quite different.⁵¹¹ Thus, the orthodontic clinician must be alert for, and be prepared to deal with, the onset or exacerbation of signs and symptoms that may occur during orthodontic tooth movement. The potential for problems clearly mandates a pretreatment TMD screening examination for all orthodontic patients.^{511,512}

Orthognathic surgery may be considered in conjunction with orthodontic or restorative or prosthodontic treatment for correction of skeletal malocclusions. However, when orthognathic surgery is considered in TMD patients, it should always follow careful evaluation confirming reasonable symptom resolution and stability of the maxillomandibular relationship. Surgical treatment for skeletal asymmetries and growth anomalies with the specific intent of alleviating pain associated with TMDs is rarely indicated and should only follow careful evaluation and management of any other contributing factors. However, in those TMD patients with severe skeletal malocclusion who desire greater occlusal stability or improved esthetics, orthognathic treatment is often the method of choice.^{513–515} Two retrospective studies showed no increase in TMD signs and symptoms in patients with juvenile rheumatoid arthritis or patients with anterior open bites who underwent orthognathic sur-

gery.^{516,517} Another study showed that in patients who underwent orthognathic surgery with rigid fixation, symptoms of clicking and muscle pain improved, whereas these symptoms increased in patients with nonrigid fixation.⁵¹⁸ A systematic review from 2010 pointed out that the studies up to that date generally had small groups, no controls, and other methodologic flaws.⁵¹⁹ A systematic review and meta-analysis from 2017 could not predict which patients might improve or worsen in TMD symptoms after orthognathic surgery.⁵²⁰ The more recent prospective studies indicate that orthognathic surgery in patients with TMDs may improve the condition; however, there are also reports of exacerbation of TMD signs and symptoms. For TMD patients who desire correction of skeletal malocclusions, orthognathic surgery is an option, but informed consent should emphasize the correction of the malocclusion, not the potential improvement in TMD.

Surgery

TMJ surgery is an effective treatment for specific articular disorders. However, the complexity of available techniques, potential complications, prevalence of behavioral and psychosocial contributing factors, and the availability of nonsurgical approaches suggest that TMJ surgery should only be used in select cases.

The decision to treat the patient surgically depends on the degree of pathology or anatomic derangement present within the joint, the potential for repair of the condition, the outcome of appropriate nonsurgical treatment, and the degree of impairment the problem creates for the patient. The appropriate duration and complexity of nonsurgical treatment prior to considering surgery are determined by a combination of factors. Factors to be considered include expected prognosis compared with actual improvement realized, the degree of impairment, and the patient's compliance with the program. Patients with complicating

factors such as pending litigation, psychologic issues, uncontrolled sleep bruxism, or prior joint surgeries may have a poor surgical prognosis. The clinician must have a full knowledge and appreciation of the potential for surgical failure and potential complications including neuropathic pain disorders (ie, deafferentation pain). Once this information is available, a realistic discussion of the prognosis, the patient's expectations, and the complicating factors can provide the patient with the information necessary to make an informed decision.

Preoperative and postoperative nonsurgical management must be integrated into the overall surgical treatment plan. This therapy is directed at decreasing the functional load placed on the joint, eliminating or modifying contributing factors such as oral parafunctional habits, and providing appropriate psychologic and medical support. The clinical practice guidelines for TMJ surgery of the American Association of Oral and Maxillofacial Surgeons state that TMJ surgery is only indicated when nonsurgical therapy has been ineffective and is not indicated for asymptomatic or minimally symptomatic cases.⁵²¹ In addition, surgery should not be performed for preventive reasons. Indications for surgery include moderate to severe pain or dysfunction that is disabling.⁵²¹ Radiographic evidence of internal derangement may be indicated. Surgical management may include joint lavage (arthrocentesis), closed surgical procedures (arthroscopy), and open surgical procedures (arthrotomy or arthroplasty), as well as total joint replacement.

Arthrocentesis

Arthrocentesis involves simple intra-articular irrigation or lavage of TMJ with or without corticosteroids or hyaluronic acid. It has been suggested this method may be as effective as arthroscopy when used with joint mobilization in the treatment of intra-articular joint restrictions of mandibular movement such as internal derangement without reduction.^{522,523} However, it

also can be used as a palliative procedure for patients with acute episodes of degenerative or rheumatoid arthritis and to relieve the pain in patients who have painful clicking in the TMJ that does not respond to medical management.^{524,525} Two reviews evaluating outcomes of arthrocentesis performed on patients with different types of internal derangement indicated successful treatment outcomes in about 80% of the cases but noted that most studies could be criticized because of methodologic flaws.^{526,527} Before the efficacy of this procedure can be confirmed, more clinical RCTs are needed.

Arthroscopy

Arthroscopy allows direct observation and sampling of the joint tissues and holds promise as a modality for treating painful joints and joints with hypomobility secondary to a persistent nonreducing displaced disc.^{528,529} Arthroscopic revision of previous open surgery has been suggested as helpful in alleviating postoperative pain and intracapsular fibrosis.⁵³⁰ At this time, arthroscopy is primarily performed in the upper joint space and is used for minor debridement and lavage, removal of minor adhesions, and biopsies. Reduction of symptoms following arthroscopic surgery is not caused by improved disc position; postarthroscopy MRI scans reveal that a vast majority of patients have persistent anterior disc displacement but increased disc mobility.^{531–538} The prognosis of arthroscopy appears comparable to that of discectomy and discoplasty.^{539–542} Because arthroscopy is less invasive than open joint surgeries, it should have preference over them whenever possible. A meta-analysis performed in 2003 showed the most robust evidence for efficacy of arthrocentesis and arthroscopy for treatment of disc displacement without reduction that was refractory to nonsurgical modalities.⁵⁴³ While a systematic review published in 2015 reported better pain control and increased maximum opening with

arthroscopy over arthrocentesis, the differences may not be clinically relevant.⁵²⁰

Arthrotomy

Open surgical intervention of the TMJ (*arthrotomy*) is usually required for bony or fibrous ankylosis, neoplasia, severe chronic dislocations, persistent painful disc derangement, and severe osteoarthritis refractory to conservative modalities of treatment.⁵²⁹ Surgery is less often indicated in displaced condylar fractures, agenesis of the condyle, and severe painful chronic arthritides. Surgery is seldom, if ever, indicated in inflammatory joint disorders (eg, synovitis or capsulitis), condylitis, and non-painful degenerative arthritis. Arthrotomy is generally indicated for patients with advanced TMJ disease who meet the surgical criteria and have disease refractory to or not amenable to arthroscopic surgical techniques.

Open joint surgical procedures may include discoplasty; disc repositioning or discectomy, with or without replacement; arthroplasty, which includes high condylectomy; and total joint reconstruction or replacements. Discoplasty and disc repositioning with plication have been reported to have an 80% to 90% success rate in reducing joint pain and noise and increasing mouth opening (although mouth opening remains short of normal ranges).^{539,544–547} The discectomy procedure without replacement has the longest history and shows good long-term success (up to 30 years).^{548–551} Use of a dermis graft in discectomy does not appear to prevent remodeling, but it may be beneficial in eliminating or preventing joint noises.⁵⁵²

The success obtained with less invasive procedures has greatly reduced the need for arthroplasty. Condylectomy (subcondylar osteotomy) and condylotomy are performed infrequently. These procedures have been indicated for more complex diseases or traumatic conditions.^{553,554} There can be more post-surgical complications with these procedures,

including marked occlusal changes. Modified condylotomy (using an intraoral vertical ramus osteotomy) in the treatment of TMJ internal derangement can reduce related pain and predictably correct disc position.^{555–557} Further controlled investigations are needed regarding these applications.

Conclusion

Despite increasing evidence that TMDs are best managed with conservative reversible treatments, some clinicians continue to choose treatments based on personal biases rather than controlled scientific investigation.^{472,494} There continues to be a need for RCTs regarding nonsurgical and surgical TMD treatment. In addition, studies designed to elucidate the etiology of TMDs are much needed. Practicing clinicians involved in the treatment of TMDs on a daily basis should be knowledgeable in clinical trial methodology and be able to critically appraise the literature upon which they base their treatments. Discriminating readers and clinicians will result, and our patients will benefit.

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9

Cervical Spinal Disorders and Headaches

Key Points

- ◇ Structures of the cervical spine can give rise to orofacial pain and headaches.
- ◇ A screening examination of the cervical spine is recommended if there is coexisting neck pain and temporomandibular disorder (TMD) pain.
- ◇ Specific and individualized interventions consisting of exercises, manual techniques, postural correction, and a home program can assist the clinician in effectively managing cervical spinal disorders to reduce pain, restore function, and prevent recurrence of complaints.
- ◇ Referral is recommended when cervical spine involvement is suspected in the development of orofacial pain complaints.

Disorders of the musculoskeletal structures of the cervical spine can contribute to the development and perpetuation of orofacial pain complaints and various headaches. Therefore, the clinician should be able to distinguish different types of neck pain, understand the mechanisms of concurrent cervical spinal pain and orofacial pain, perform a screening evaluation of the cervical spine, and initiate appropriate referral for further evaluation and comprehensive management when indicated.

Defining Cervical Spine Disorders

Cervical spine disorders (CSDs) encompass a wide variety of disorders involving the musculoskeletal structures, discs, and nerves of the cervical spine. The most common symptoms of a CSD are neck pain and movement limitations. Head movements or sustained head postures usually aggravate the pain. Although neck pain may be a feature of virtually every disorder or disease of the upper quadrant, it is only rarely a symptom of a serious pathology such as tumors or infections. If there is neurologic involvement, pain can radiate toward the head, trunk, or upper limbs.

Subclassification of CSDs includes an extensive list of diagnostic terms, such as *cervicalgia*, *cervical sprain/strain*, *discogenic disease*, and *facet syndrome*.¹ In the absence of pathology or systemic disease, neck pain is usually referred to as *nonspecific*. For the most common types of neck pain, the Neck Pain Task Force introduced a classification system to facilitate communication among health care professionals (Box 9-1).² This classification system differs from earlier classification systems for neck pain and lower back pain in that the decision for further assessment and treatment depends not only on the clinical signs but also on the presence of disability.^{4,5}

This chapter presents common CSDs that may be associated with orofacial pain or headaches and provides questionnaires to rate the level of disability related to neck pain. Together, these tools will help the clinician to assess whether the cervical spine is involved in the patients' orofacial pain complaints and whether referral for additional assessments or treatment is necessary.

Epidemiology of CSDs

Most people will experience some neck pain in their lifetimes, but for the majority, neck pain will not seriously interfere with daily

Box 9-1 Neck Pain Task Force classification system for neck pain²

| | |
|-----------|---|
| Grade I | <ul style="list-style-type: none">• Neck pain without signs of pathology, low disability• Likely to respond to minimal intervention, such as reassurance and pain control• Does not require intensive investigations or ongoing treatment |
| Grade II | <ul style="list-style-type: none">• Neck pain without signs of pathology, high disability• Requires pain relief and early activation aimed at preventing long-term disability |
| Grade III | <ul style="list-style-type: none">• Neck pain with neurologic signs• Might require investigation and, occasionally, more invasive treatments |
| Grade IV | <ul style="list-style-type: none">• Neck pain with signs of pathology, such as fracture, infection, myelopathy, neoplasm, or systemic disease• Requires prompt investigation and treatment |

Note: This chart provides an overview of the classification system. For the full description, see the original report.³

activities.² One-year prevalence estimates of neck pain range from 30% to 50% in the general population, while 1-year incidence estimates of neck pain with associated disability range from 2% to 14%.² The prevalence of

neck pain increases with age up to the fifth decade and then decreases, and it is higher among women than men.^{2,6} Between 50% and 85% of those who experience neck pain at one point will report neck pain again 1 to 5 years later.^{7–9} Psychologic stress, prolonged forward head posture, and repetitive cervical movements increase the risk for developing neck pain.^{10–12} The influence of repetitive movements and sustained head positions is reflected in the high prevalence of neck pain in specific populations, such as dentists, professional drivers, and adolescents with prolonged computer use.^{13–16}

Relationship Between CSDs and Orofacial Pain

Many studies have reported the coexistence of TMDs and CSD symptoms.^{17–21} In a large study of the general Dutch population, complaints of neck pain were twice as prevalent in patients with TMD pain (71% to 85%) compared with persons without TMD pain (39%).²² A case-control study on adolescent TMD patients also revealed a prevalence for neck pain over twice that in controls of the same age and sex.²³ Both studies also found strong associations with headache, back pain, and more widespread pain. In addition, a strong relationship was found between neck disability and jaw disability.²⁴ Several mechanisms have been suggested to explain this coexistence of TMD pain and neck pain, including sensitization, biomechanics, and genetics. This common co-occurrence requires health care professionals who manage orofacial pain to also have knowledge of neck pain.²⁴

Peripheral and central sensitization

Sensitization of the nervous system occurs when persistent nociceptive facilitation exceeds its inhibitory capacity. In this situation,

a spectrum of neuroplastic changes occurs, such as lowered nerve thresholds, enlarged receptive fields, and changed gene expression. *Peripheral sensitization* refers to the situation of increased responsiveness and reduced threshold of peripheral neurons.²⁵ *Central sensitization* refers to the increased responsiveness of nociceptive neurons in the central nervous system to their afferent input.²⁶ Patients may have *allodynia* (experience of pain by stimuli that normally would not be perceived as painful) and *hyperalgesia* (exaggerated pain responses to painful stimuli). For more details on sensitization, see chapter 1.

Craniofacial pain is mediated by the upper cervical nerves, the sinuvertebral nerves of C1 to C3, and cranial nerves V, VII, IX, X, XI, and XII. Additional innervation is provided by sympathetic afferents that course with the first two thoracic nerves synapsing in the trigeminal nucleus, as well as parasympathetic afferents traveling with cranial nerves VII and IX.²⁷ Further reading is recommended on the innervation of the head and neck region, and anatomy books will also be helpful on this subject.^{28,29} Convergence of afferents of the cervical spinal nerves and the trigeminal nerve, together with increased responsiveness of the central nervous system, may explain the frequent coexistence of neck pain and orofacial pain. These nerves carry afferent input from various tissues of the head and neck and meet in the trigeminal spinal nuclei.²⁷ Consequently, nociceptive input from cervical structures can be referred to the orofacial region, and vice versa. Several experimental studies have demonstrated this mechanism. For example, Piovesan et al³⁰ showed that after painful stimulation of the greater occipital nerve, the participants experienced pain not only in the innervation area of that nerve but also into the projection area of the trigeminal nerve (ophthalmic division, V1 distribution). In another study,³¹ glutamate-evoked pain in the splenius capitis muscle (innervated by C3 and

C4) caused referral of pain to the temporal region. Even though glutamate injections into the masseter muscle (innervated by the mandibular division of the trigeminal nerve, V3) did not result in referral of pain to the neck region in that particular study, other studies have provided evidence for a bidirectional relationship in convergence of afferents from the trigeminal and upper cervical neural systems.^{32–35}

Genetics

For both experimental pain and clinical pain, evidence for the contribution of genetic factors to individual differences in pain is evolving.³⁶ For TMD pain, there is cumulating evidence for a genetic predisposition.³⁷ In 2011, Maixner et al³⁸ presented a model for the development of TMD pain that proposed that TMD pain is influenced by psychologic distress and pain amplification (eg, allodynia, hyperalgesia, and central sensitization), which in turn are subject to genetic regulation and environmental input. The mechanisms contributing to pain amplification are thought to relate to a decreased function in pain inhibition as well as increased function of pain-facilitating pathways. An example of such a pain inhibitory system is the serotonergic system. A newer study has been able to replicate earlier findings that a polymorphic variant (ie, the CC genotype) of the 5-hydroxytryptamine receptor 2A (*5-HTR2A*) gene is more prevalent in TMD-pain patients than in controls.³⁹ The serotonin receptor is suggested to have antinociceptive effects. Lower serotonergic activity (eg, by less active postsynaptic receptors) may therefore lead to a decreased ability to stimulate the central descending analgesic system and result in higher levels of pain.⁴⁰ Another candidate gene for involvement in musculoskeletal pain is the catechol-O-methyltransferase (*COMT*) gene. Variants of this gene are reported to be associated with fibromyalgia, neck pain, and TMD pain.^{36,41–43}

Biomechanical relationship

The cranium and the mandible both have muscular and ligament attachments to the cervical area, forming a functional system called the *craniocervical mandibular system* or *stomatognathic system*. Because of this close functional coupling, changes in the activity of the neck muscles and head position influence the activity of the masticatory muscles and jaw function, and vice versa.^{44–47} When the mandible is at rest, its position is determined by the viscoelasticity of the muscles and the postural muscle tone acting on the mandible.⁴⁴ With an upright head position, the relaxed mandible maintains a fairly constant distance from the maxilla of approximately 2 to 5 mm.⁴⁸ When the head is held in a forward position, the condyles are pulled slightly downward during open-close movements.⁴⁹ Jaw opening and closing movements, as during eating, are accompanied by respective extension and flexion of the head, and several neck muscles are co-activated during jaw clenching.^{46,47,50,51}

As a result of these synergistic relationships between the structures of the masticatory system and the neck and the coexistence of TMDs and CSDs, poor head posture (mostly a forward head posture) and overload of the cervical spinal musculature have been suggested as etiologic factors for TMDs.^{52,53} Clinical studies regarding such relationships, however, show contradictory results.⁵⁴ Even though some authors have reported small differences in head posture between TMD patients and healthy controls, the clinical relevance of these differences has been disputed, and other studies did not even find differences in head posture between TMD patients and controls.^{24,55–57} So although there is vast evidence showing the functional coupling between the musculoskeletal structures of the cervical spine and the masticatory system, there is only weak evidence for a direct biomechanical mechanism (eg, the effect of poor head posture on the masticatory system) as a cause for TMDs.^{54,58}

Box 9-2 Red flags for serious pathology in neck pain patients with no exposure to blunt trauma²

- Pathologic fractures (eg, resulting from decreased bone density caused by osteoporosis or corticosteroid treatment)
- Neoplasms (eg, previous history of cancer, unexplained weight loss)
- Failure to improve after a month of evidence-based therapy
- Cervical myelopathy
- Systemic diseases (eg, inflammatory arthritis)
- Infections
- Intractable pain or tenderness over the vertebral body
- Prior neck surgery

Conclusion

The examples of sensitization, genetics, and biomechanical interplay between the structures of the head and neck illustrate that CSDs may influence pain in the orofacial region. Therefore, the cervical spine needs to be considered in the assessment of patients with orofacial pain complaints.⁵⁹ It is quite common for physical therapists to evaluate patients who present with cervical pain as well as craniofacial pain because of the comorbidity between the disorders.^{17–21,33,60} A clinical evaluation of the cervical spine and temporomandibular complex helps to determine whether the complaints originate from the neck, the masticatory region, or a combination of both.

Screening of the Cervical Spine

As described in Box 9-1, the Task Force on Neck Pain introduced a four-grade classi-

fication system of neck pain severity. Because few major differences were found between trauma-related neck pain and neck pain with a nontraumatic etiology, the classification is recommended for all individuals who seek clinical care.² To use the classification system, information is needed on serious pathology, disability, and signs of nerve compression.

Serious pathology

For patients without exposure to blunt trauma, the Task Force on Neck Pain suggests ruling out serious pathology based on existing recommendations for the lumbar spine (Box 9-2).^{2,61} The presence of such red flags should prompt the clinician to seek additional evaluation and care for such patients. Though a full discussion is beyond the scope of this chapter, the Canadian C-Spine and NEXUS protocols provide an overview of screening protocols for neck pain patients seeking emergency medical care, mostly following a trauma.⁶²

Disability

Several reliable and valid self-assessment questionnaires are available to determine the level of disability in neck pain patients, including the Neck Disability Index⁶³ and the Neck Bournemouth Questionnaire.⁶⁴ Within this framework, the Graded Chronic Pain Scale (GCPS)⁶⁵ is of special interest because it is a universal system that can be used for any pain condition (eg, neck pain, headache, or temporomandibular pain), it is easy to use, and it is the most commonly used system to rate disability in scientific publications on TMD patients. In this system, GCPS grades 3 and 4 represent patients with high disability. According to the Task Force on Neck Pain, patients experiencing such pain-related disability require further assessment and treatment to prevent long-term disability (see Box 9-1).

Table 9-1 Testing procedures of manual provocation tests for cervical radiculopathy⁶⁷

| Name | Description | Positive test outcome |
|--------------------------|---|----------------------------------|
| Spurling test | The patient is seated. The neck is passively bent sideways toward the symptomatic side, and overpressure (approximately 7 kg) is applied to the patient's head.* | Symptom reproduction |
| Neck distraction test | The patient is supine. The neck is passively flexed to a position of comfort, and a gradual force of distraction (up to 14 kg) is applied to the patient's head.* | Symptom reduction or elimination |
| Valsalva maneuver | The patient is seated and instructed to take a deep breath and hold it while attempting to exhale for 2 to 3 seconds. | Symptom reproduction |
| Upper limb tension test* | The patient is supine. A sequence of movements is passively performed to elongate the median nerve: depression of the scapula, abduction and external rotation of the shoulder, extension of the elbow, supination of the forearm, and dorsiflexion/extension of the wrist. | Symptom reproduction |

*Note: Passive evaluation of the neck should not be attempted unless the clinician has had specific training in this technique.

Signs of nerve compression

Nerve compression should be suspected in patients with neck pain that radiates to the arm (for a detailed description of this condition, see Radiculopathy below). Neck pain from this origin is caused by an irritation of the cervical nerve root, mostly due to prolonged compression. In typical cases, the irradiating pain closely follows the area innervated by the affected nerve root. When nerve compression is suspected, a cluster of clinical provocation tests is recommended, such as the Spurling test, traction/neck distraction, Valsalva maneuver, and upper limb tension test.⁶⁶ A summary of the testing procedures is presented in Table 9-1. These diagnostic procedures have high predictive value when compared with gold standards of nerve conduction/magnetic resonance imaging and myelography.² The Spurling test, traction/neck distraction, and Valsalva maneuver have high specificity, so positive test results might be suggestive of nerve compression when they are consistent with the history and other physical findings. The upper limb tension test, on the other

hand, has high sensitivity, so a negative result is highly suggestive of the absence of nerve compression.

In the absence of acute trauma and symptoms of serious pathology, the use of diagnostic procedures such as routine imaging, anesthetic facet or medial branch blocks, or surface electromyography for the diagnosis of nerve compression is not supported by the literature.²

Additional diagnostic procedures for neck pain

The clinical physical examination of the neck, like that for back pain, is generally better at ruling out a radiculopathy than at diagnosing other specific etiologic conditions for neck pain.² Still, a screening clinical examination often includes a chronologic history (including past and current treatments, functional limitations, and successful pain modifiers), assessment of the active and passive range of motion, palpation of the cervical spine and associated muscles, and dynamic and static resistance tests of the neck.^{68–70} Additional studies are needed for the validity of these

Table 9-2 Diagnostic procedures for the management of neck pain

| Name | Description | Positive test outcome |
|------------------|---|--|
| Range of motion | Active and passive* range of motion is observed during flexion, extension, rotation, and side bending head movements. | Limited or irregular movements and/or reproduction of neck pain |
| Palpation | Important cervical muscles or muscle groups to evaluate are the sternocleidomastoid, suboccipital, paravertebral (scalenes), posterior deep cervical, and upper trapezius muscles. | Symptom reproduction |
| Resistance tests | Dynamic (head movements against a slight manual resistance) and static (strong manual resistance while no movement occurs) resistance tests are performed in the same directions as described by range of motion. | Symptom reproduction (more dynamic than static pain is indicative of arthrogenous pain; more static than dynamic pain is indicative of myogenous pain) |

*Note: Passive evaluation of the neck should not be attempted unless the clinician has had specific training in this technique.

diagnostic procedures, but evidence is growing, and they are widely used and considered to provide useful information for prognosis and management (eg, options for treatment or evaluation of outcome).^{69,71–73} It is recommended to cluster findings of multiple tests because this increases the diagnostic value.⁷⁴

It is beyond the scope of this chapter to describe a thorough examination of the cervical spine, but a short overview of the most common clinical tests for neck pain is provided in Table 9-2. If further evaluation of the cervical region is indicated, patients should be referred to an appropriately trained clinician (eg, a physical therapist with special training in the craniocervical region). Similar to other musculoskeletal disorders, such as TMDs and back pain, the finding of degenerative changes on imaging has not been shown to always be associated with neck pain.²

Common CSDs

While it is important for the clinician to be aware of cervical etiologic factors that can contribute to the presence or perpetuation of orofacial pain, cervical disorders should not

be managed in the dental setting. Orofacial pain patients with a CSD should be referred to a physical therapist with special training in the craniocervical region (eg, a physical therapist registered by the Physical Therapy Board of Craniofacial and Cervical Therapeutics [PTBCCT] or a cervical spine specialist) for thorough evaluation and treatment.⁷⁵ The remainder of this chapter highlights some of the more common CSDs that can contribute to the experience of orofacial pain and headaches and includes their codes according to the International Classification of Headache Disorders, third edition (beta version) (ICHD) and The International Classification of Diseases, *Tenth Edition* (ICD-10). This overview should be considered a description of possible causes of neck pain, allowing pattern recognition but not claiming criteria for objective diagnoses. In most cases, the below-mentioned CSDs fulfill the criteria for grade I or II of the Neck Pain Task Force classification system.²

Cervicalgia (ICD-10 M54.2)

Cervicalgia is a broad term meaning pain in the neck and represents the most common neck pain complaints. Although the pain may origi-

nate from any cervical structure, discomfort is primarily felt in the suboccipital area and sternocleidomastoid (SCM) and upper trapezius muscles, with possible referral to the frontal, temporoparietal, occipital, vertex, and orbital regions. The Task Force on Neck Pain defined neck pain as symptoms “located in the anatomical region of the neck with or without radiation to the head, trunk, and upper limbs.”⁷⁶ Treatment of cervicgia includes conservative techniques such as cervical physical therapy. This consists of advice, mobilizations, and exercise, which are often combined. The evidence for the effectiveness of this multimodal approach in the short, intermediate, and long term is growing and has been translated into clinical practice guidelines.^{77–79}

Sprain and strain of cervical spine (ICD-10 S13.4)

The most frequent traumatic spinal injury encountered in medical practice is a sprain or strain of the cervical spine following a motor vehicle accident, also known as a *flexion/extension injury*, *acceleration-deceleration injury*, and *whiplash-associated disorder (WAD)*.⁸⁰ Similar to cervicgia, or common neck pain, WADs are usually graded as grade I and II. Neck symptoms without or with only minor interference with activities in daily life (ADL) would be considered grade I, and neck symptoms with substantial interference with ADL are grade II. Grade III is reserved for those patients with neurologic signs (radiculopathy), and grade IV for those with major structural pathology in the anterior, posterior, or lateral structures of the cervical spine, as well as parts of the shoulder girdle.^{80–85} The incidence of resultant neck pain and postural changes is significant.^{80,82,84,85} Patients with a WAD have significantly more signs and symptoms of TMDs when compared with healthy controls, as well as compared with neck-pain patients without a traumatic onset of their complaints.^{86–90} However, when other physical

pain complaints are accounted for, the higher prevalence of TMD pain is found to be merely part of a more general widespread pain disorder in WAD patients.⁹⁰

The onset of neck pain following acute trauma may occur immediately or with a delay of up to 2 days. It may occur as an ache or stiffness in the neck. Pain referral to sites distant from the original injury is common, as is the presence of headache, dizziness, tinnitus, dysphagia, and visual disturbances.^{82,84,91,92} Most patients show recovery after a whiplash trauma in the first 3 months. Thereafter, little improvement is seen. Because a large proportion of patients (even up to 50%) will not recover completely, WAD is a therapeutic challenge.^{80,93,94} Prognostic indicators to assess the risk of poor recovery are high scores on the Neck Disability Index, age of 40 years or older, and signs of hyperarousal.^{93,95}

For grades I and II, treatment primarily consists of rest, relative immobilization (ie, act as usual but temporarily prevent extreme movements and exercises), and, when necessary, anti-inflammatory drugs or muscle relaxants until the patient is pain free and has regained full mobility of the cervical spine. When recovery is delayed (ie, complaints are still present after 3 to 6 weeks), referral for further therapy should be considered. Conservative treatments including active exercise, manual techniques, and physical therapy can be useful to reduce pain and increase cervical range of motion.⁹⁶ If the complaints are still unresolved 6 to 12 weeks after onset, referral to a multidisciplinary team is recommended.⁸¹

In the past, cervical collars were frequently prescribed to immobilize the neck in WAD patients. Several studies have evaluated the additional effect of soft collars on WAD patients and found that soft collars in combination with other interventions resulted in delayed recovery in terms of pain and range of motion.⁸¹ Therefore, the use of soft collars is no longer recommended to prevent inactivity of the cervical spine.⁸¹

Cervical osteoarthritis (ICD-10 M47.8)

With increasing age, degenerative changes can occur in the vertebral body, adjacent uncinate processes (joints of Luschka), posterior facet areas, and intervertebral discs.^{97,98} Degenerative changes include inflammation of the joint linings with osteophyte formation, along with bony and cartilaginous exostoses. The most common regions of degenerative changes of the intervertebral disc are in the area of C5 to C6 and C6 to C7.⁹⁹ Osteoarthritis (OA) of the synovial joints is more commonly found in the more mobile upper cervical segments.⁹⁷

OA is common in individuals over the age of 50 years. By the seventh decade of life, 75% of individuals display signs and symptoms of OA, and it is generally considered that 100% of individuals will develop signs and symptoms of OA during the course of a normal lifetime.⁹⁸ As the elasticity of tissues decreases with age, there is a concomitant loss of range of motion, the neck becomes less resilient, and muscle strength declines. Early subjective complaints of OA include occasional episodes of neck pain triggered by activity. These episodes often resolve in a couple of days with little more than rest (ie, act as usual but temporarily prevent extreme movements and exercises). More advanced symptoms include stiffness, limitation of movements, crepitus, and chronic neck pain. Progressive degeneration can lead to narrowing of the intervertebral spaces and may result in radiculopathy. However, no association between degenerative changes on imaging and neck pain has been found, indicating that degenerative changes without pain and vice versa are common findings.²

Mild and moderate stages of cervical OA will normally respond to comprehensive physical therapy management, including mobilization, exercise, and transcutaneous electrical nerve stimulation, with or without medication.^{100,101} However, once osteoarthritic

changes have reached the point of neural compression and radiculopathy (grade III or IV of the Task Force on Neck Pain), remission of symptoms is more difficult and the patient should be referred to a medical specialist (eg, a neurologist or an orthopedist).

Radiculopathy (ICD-10 M54.1)

Radiculopathy is a pain and/or sensorimotor deficit syndrome caused by compression of a nerve root. The compression can occur as a result of disc herniation, spondylosis, instability, trauma, or—rarely—tumors. Patient complaints related to radiculopathy in the cervical region range from pain, numbness, and/or tingling in the upper extremity to electric-type pains or even weakness.¹⁰²

The cervical spinal nerves are named corresponding to the vertebral body below the nerve.²⁶ Radicular pain from the C2 nerve roots can manifest itself as eye and/or ear pain and headache.¹⁰² In addition, involvement of the C1 to C3 nerve roots may be accompanied by suboccipital or occipital headaches, neck pain, or pain referred to the shoulder girdle region.^{70,102}

Radiculopathies are not managed by the dentist and should be referred to the proper health professional for evaluation and management. Further reading may include guidelines such as *The Clinical Guideline for the Diagnosis and Treatment of Cervical Radiculopathy from Degenerative Disorders*.¹⁰³

If space-occupying lesions or malignant processes have been ruled out as the source of the pain, comprehensive noninvasive treatment may include physical therapy. There is widespread indication that prolonged use of a cervical collar leads to deconditioning of the neck musculature and tissue damage; hence, such use should be avoided.¹⁰² Active interventions with education, instructions in proper postural techniques, and therapeutic exercises are more favored in the literature.^{104,105}

Cervical dystonia (ICD-10 G24.3)

Cervical dystonia, or *spasmodic torticollis*, is a condition characterized by sustained contractions of the neck muscles and sometimes the shoulder muscles.¹⁰⁶ The head is typically tilted laterally, bending toward the affected muscle and rotated toward the opposite side. It may be spasmodic (clonic) or permanent (tonic). Bilateral SCM involvement will yield the head in an extended position (retrocollis) and is often associated with dysphagia and vocal disturbances.¹⁰⁷ It can be a primary (idiopathic) or secondary condition. Secondary cervical dystonias can be a consequence of disease processes (eg, Wilson disease), or they may be linked to the use of medications (eg, neuroleptics) or excessive toxin introduction into the body (eg, carbon monoxide poisoning).¹⁰⁷ Structural lesions, primarily of the basal ganglia, such as trauma or vascular insults, can also be a cause.¹⁰⁷ Cervical dystonia is one of the most common forms of focal dystonia, occurring in approximately 5 per 100,000 individuals in the general population.¹⁰⁸ A recent meta-analysis revealed no significant differences between men and women, with a prevalence of 6.5 per 100,000 in women and 5.0 per 100,000 in men.¹⁰⁸ Cervical dystonias usually develop from age 45 years (ie, late-onset).¹⁰⁷ Although pain is not the dominant complaint of patients with other types of dystonia, cervical dystonia is an exception, with 75% of the patients reporting neck pain.¹⁰⁷ The usual treatment for torticollis is botulinum toxin injection.¹⁰⁹ Usually, these injections need to be readministered every couple of months. A relatively common side effect of botulinum injections is dysphagia (problems with swallowing). Bilateral SCM injections are more often associated with dysphagia. It is usually mild (severe in less than 5% of cases) and disappears gradually after 2 to 3 weeks.¹⁰⁹ Studies as to the additional effects of behavioral interventions in cervical dystonia are scarce and usually of low methodologic quality. The limited data indicate,

however, that behavioral therapies including cognitive behavioral and relaxation exercises could have a beneficial effect for enabling individuals to manage their dystonia.¹⁰⁹

Occipital neuralgia (ICHD 13.4; ICD-10 G52.8)

Occipital neuralgia is a primary headache disorder characterized by paroxysms of sharp, shooting occipital pain that last for seconds to minutes. The pain is associated with dysesthesia and/or allodynia in the area and tenderness over the affected nerve branches.¹¹⁰ The pathogenesis is unknown, and most cases are considered idiopathic. In some cases, head trauma or nerve entrapment has been suggested as a cause of occipital neuralgia.¹¹¹ The differential diagnosis includes migraine, cluster headache, hemicrania continua, tension-type headache, and temporal arteritis involving the occipital artery.¹¹¹ Occipital referral of pain from the atlantoaxial or upper zygapophyseal joints, resulting in cervicogenic headache, should also be considered in the differential diagnosis, as should neoplasms or other destructive lesions affecting the spine or occiput.^{111,112}

Initial conservative treatment including physical therapy directed at alleviating secondary muscle tension and improving posture is often an effective approach.¹¹² Low-dose antiepileptic drugs and tricyclic antidepressants may reduce acute pain, while refractory cases may respond to pulse radiofrequency or occipital nerve stimulation.¹¹¹

Head or facial pain attributed to inflammation of the stylohyoid ligament (ICHD 11.8)

This type of head or facial pain, previously called *Eagle syndrome*, is a rare condition that is caused by inflammation of the stylohyoid ligament.¹¹³ The pain is generally perceived in the oropharynx, neck, and/or face, but some

patients experience a more diffuse headache. This type of headache is usually unilateral, with neck, pharyngeal, and/or facial pain that is provoked by turning the head. Examination should include palpation of the stylohyoid ligament and/or provocation tests, such as turning the head in ipsilateral as well as contralateral directions. Radiographic examination will reveal an elongated or calcified stylohyoid process and/or stylohyoid ligament.¹¹⁴ Pain is significantly improved by local injection of local anesthetics or by styloidectomy.¹¹³ Treatment may consist of pharmacologic management with analgesics or anti-inflammatory agents and/or surgical excision via either an intraoral or extraoral approach.^{115–117}

Cervicogenic headache (ICHD 11.2.1; ICD-10 G44.841)

Cervicogenic headache is described as a “headache which is caused by a disorder of the cervical spine and its component bony, disc and/or soft tissue elements, usually but not invariably accompanied by neck pain.”¹¹⁰ To classify this type of headache, there should be evidence of a cervical disorder or lesion with a known ability to cause headache. In addition, at least three of the following criteria should be present: (1) headache has developed in temporal relation to the onset of the cervical disorder or lesion, (2) headache has significantly improved or resolved in parallel with improvement in or resolution of the cervical disorder or lesion, (3) cervical range of motion is reduced and headache is made significantly worse by provocative maneuvers, and (4) headache is abolished following diagnostic blockade of a cervical structure or its nerve supply.¹¹⁰ Features that tend to distinguish this type of headache from migraine and tension-type headache (while not unique for cervicogenic headache) include side-locked pain, provocation of the typical headache by

digital pressure on neck muscles and by head movement, and posterior-to-anterior radiation of pain.^{110,118} It should be noted that the coexistence of headache and neck pain does not automatically imply a causal relationship. Manipulative therapy and exercise can reduce the symptoms of cervicogenic headache.¹¹⁹

In the ICHD, the condition formerly known as *neck-tongue syndrome* is now encompassed by the less specific diagnosis of *cervicogenic headache*.^{110,120} The understanding of the neck-tongue syndrome pathology involving C2 nerve root entrapment by subluxation of the atlantoaxial joint is better accounted for by cervicogenic headache than by its previous classification as a cranial neuralgia. It is a rare disorder characterized by abrupt unilateral pain in the neck or occiput with associated abnormal sensation involving the ipsilateral tongue and precipitated by sudden neck movements.¹²⁰ It has a duration of seconds to minutes.¹²⁰ The proposed mechanism for neck-tongue syndrome involves subluxation of the atlantoaxial joint, producing neck pain and irritation of the C2 nerve.¹²¹ In the absence of pathologic findings, the disorder appears benign, and it is treated conservatively. Reported treatments mostly from case reports involve nonsteroidal anti-inflammatory drugs, antiepileptics, antidepressants, corticosteroids, muscle relaxants, injections of local anesthetics, cervical collars for immobilization, and postural correction with patient education.^{120,122}

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Extracranial and Systemic Causes of Head and Facial Pain

Key Points

- ◇ Clinicians treating orofacial pain patients should inquire about symptoms in other areas of the body to exclude systemic diseases as an etiology.
- ◇ Several systemic conditions may lead to head and facial pain; therefore, it may be a symptom of a serious underlying disease.
- ◇ Because pain can be primary or referred, it is necessary to identify and treat the underlying cause and refer to a specialist if necessary.

Although head or facial pain frequently arises from teeth or other masticatory structures, it can originate from any of the tissues or organs in the head and neck or from systemic diseases. In the case of head or facial pain associated with a serious or life-threatening illness, timely recognition and referral to a physician are crucial. In cases where the cause of head or facial pain is not readily apparent, nonmasticatory, extracranial, and systemic pain sources should be considered in a differential diagnosis. This chapter briefly summarizes these pain sources based on the current classification format of the International Headache Society (IHS)¹ and provides lists of associated disorders and symptoms for easy reference. For further information and treatment guidelines, the reader

Box 10-1 Head and facial pain arising from the eyes**Primary pain**

- Acute glaucoma (IHS 11.3.1)
- Convergence disorders (heterophoria or heterotropia) (IHS 11.3.3)
- Ocular inflammation (IHS 11.3.4)
- Corneal diseases
- Painful ophthalmoplegia
- Superior orbital fissure syndrome
- Orbital tumors
- Metastatic tumors
- Orbital schwannomas
- Orbital lymphomas

Referred pain

- Saccular aneurysms (IHS 6.3.1)
- Cavernous sinus inflammation
- Carotid-cavernous fistula (IHS 6.3.3)
- Carotid artery dissection (IHS 6.5.1)
- Myofascial pain
- Orbital apex syndrome
- Parasellar syndrome

is referred to other chapters in the text or to standard medical references.

Pain Stemming from Tissues or Organs in the Head and Neck

Cranial bones (IHS 11.1)

Most lesions that affect the bones of the skull are nonpainful.² Although it is unusual for pain to arise from the cranial bones, any pain that does arise is derived from nociceptors of the underlying periosteum. Lesions of the skull most likely to produce headache are those that are rapidly expansile or aggressively osteoclastic or those that have an inflammatory component.³ Included in this group of lesions are

osteomyelitis, multiple myeloma, sickle cell disease, Paget disease, osteopetrosis, eosinophilic granuloma, Langerhans cell histiocytosis, osteoblastoma, immunoglobulin G4-related disease, non-Hodgkin lymphoma, and metastatic tumors.^{4–10}

Eyes (IHS 11.3.x)

Patients with eye pain will most often have obvious ocular signs accompanying the pain, making diagnosis relatively easy in such cases. However, there are occasional instances of headache or facial pain originating in the eyes without obvious ocular signs, making diagnosis more difficult. Ocular pain may be either primary or referred (Box 10-1). Primary pain arises from the ophthalmic division of the trigeminal nerve, although the maxillary division supplies most of the lower eyelid through its infraorbital branch.¹¹ The retina and optic nerve are not capable of nociception, but the cornea, conjunctiva, iris, extraocular muscles, dural sheath of the optic nerve, and periorbital area are supplied with pain-sensing nociceptors. Pain may be perceived as originating in the orbit by stimulation of the optic nerve at any point along its path from the face to the cortex. Possible stimuli include intracranial tumors, tumors of the orbit or paranasal sinuses, cavernous sinus inflammation, and carotid aneurysms.¹² Facial, cervical, and pericranial muscles are common sources of pain that may be referred to the orbit or periorbital areas.¹³

Ocular pain associated with inflammation is often accompanied by photophobia and conjunctival injection. Pain with eye movement can be due to optic neuritis or anterior sinusitis. Refractive errors are unlikely to be the cause of eye pain or headache. Although headache is often accompanied by ocular or periorbital pain, in the absence of ocular or periocular findings, it should be assumed the pain is not due to a primary ocular disorder, and further testing should be performed.¹⁰ Metastatic tumors to the orbit may present with diplopia (48%),

pain (42%), and visual loss (30%) as the most common symptoms. Breast carcinoma (29%), melanoma (20%), and prostatic cancer (13%) are the most common cancers that metastasize to the orbit.¹⁴ Orbital infarctions secondary to sickle cell disease cause acute periorbital pain, proptosis, ophthalmoplegia, and visual impairment.^{14–16} Orbital schwannomas are benign, well-encapsulated, slowly progressive tumors that may cause symptoms of proptosis, blurred vision, pain, eyelid swelling, diplopia, or headache.¹⁷ Orbital lymphomas can present with proptosis, eyelid lesions, tearing, chemosis, decreased visual acuity, ptosis, pain, squint, and optic nerve compression.¹⁸

Ears (IHS 11.4)

About 50% of earaches are due to structural lesions of the external or middle ear.¹⁹ The remainder of earaches involve referred pain arising from disorders such as toothache, temporomandibular disorders (TMDs), pharyngeal or laryngeal disorders, and cervical disorders.^{20,21} Sensory innervations of the ear are supplied by numerous nerves, including branches of the 5th, 7th, 9th, and 10th cranial nerves, in addition to branches of the 2nd and 3rd cervical nerves. Thus, pain originating in the regions that supply these numerous nerve branches may be perceived as pain in or around the ears.

Primary painful disorders of the ear can originate in the auricle, external ear canal, tympanic membrane, or middle ear (Box 10-2). The common causes of primary otalgia include otitis media, otitis externa, foreign body, and barotrauma.²² Primary otalgia may also be accompanied by other symptoms including vertigo, deafness, or tinnitus.²³ Benign lesions originating in the temporomandibular joint (TMJ) have been reported to present as masses in the external auditory canal. These lesions include pigmented villonodular synovitis, nodular fasciitis, foramen tympanicum herniation with salivary fistula, fibroepithelial polyp, superficial angiomyxoma, and giant cell

Box 10-2 Head and facial pain arising from the ears

Primary pain

- Otitis media
- Otitis externa
- Foreign body
- Barotrauma
- Cholesteatoma (IHS 11.4)
- Mastoiditis
- Ramsey Hunt syndrome
- Herpes simplex
- Herpes zoster
- Tumors

Referred pain

- Temporomandibular disorders
- Myofascial pain
- Toothache
- Auriculotemporal syndrome
- Carotid artery dissection (IHS 6.5.1)
- Red ear syndrome
- Sinuses
- Pharyngitis or tonsillitis
- Cervical spine arthritis
- Pigmented villonodular synovitis
- Nodular fasciitis
- Foramen of Huschke herniation
- Fibroepithelial polyp
- Superficial angiomyxoma
- Giant cell tumor

tumor. Symptoms include TMJ pain, hearing loss, and otalgia.²⁴

The prevalence of otologic signs and symptoms in adult patients with TMD is high. The most common otologic symptoms in patients with TMD are ear fullness, tinnitus, and ear pain.²⁵ Tinnitus—particularly pulsatile tinnitus—reported in patients with TMD caused a moderate impact on quality of life and can be seen in the presence of background noise, although daily activities can still be performed.²⁶

Box 10-3 Head and facial pain arising from the nose and paranasal sinus complex

Primary pain

- Rhinosinusitis (IHS 11.5)
- Acute or chronic sinusitis (IHS 11.5)
- Vestibulitis
- Septal deviation
- Hypertrophic turbinates
- Nasal polyposis
- Septal abscess/hematoma
- Sarcoidosis
- Wegener granulomatosis
- Tumors
- Infections

Referred pain

- Toothache
- Temporomandibular disorders
- Myofascial pain
- Migraine
- Tension-type headache
- Pharyngeal pain

Nose/paranasal sinus complex

The nasal cavity is surrounded by the paranasal sinuses, which include the maxillary, ethmoid, frontal, and sphenoid sinuses. Sensory innervation of the nasal/paranasal sinus complex is supplied by the first and second divisions of the trigeminal nerve.¹⁴ Normal function of the sinuses is dependent upon ciliary action that actively transports mucous and debris to the ostia to allow drainage into the middle meatus of the nasal cavity. If the ostia become blocked due to inflammation or obstruction, fluid and bacteria accumulate, leading to signs and symptoms of sinusitis. Acute rhinosinusitis is typically sudden in onset, lasts up to 4 weeks, and resolves with antibiotic treatment. Chronic rhinosinusitis lasts longer than 12 weeks. The symptoms of acute or chronic rhinosinusitis commonly include nasal obstruction, nasal congestion, nasal

discharge, nasal purulence, postnasal drip, facial pressure and pain, alteration in the sense of smell, cough, fever, halitosis, fatigue, dental pain, pharyngitis, otalgia, and headache.²⁷

It is noteworthy that in a study of the symptoms of acute sinusitis, maxillary toothache was highly specific (93%), but only 11% of patients with sinusitis actually had pain from the tooth.²⁸ Headache had a sensitivity of 68% but only a specificity of 30%. *Sinus headache* is a term that is very nonspecific and often confused with migraine and tension-type headache because of similarity in location of the headache. Some studies have shown that up to 90% of sinus headaches are actually migraines (migraine with sinus symptoms).^{29,30} No precise clinical definition exists for what constitutes a sinus headache, which has always been a diagnostic dilemma. Contrary to popular belief, headache is not a typical symptom of rhinosinusitis. Nevertheless, patients may self-diagnose sinus headache, ignoring the neurogenic causes of the symptoms and being unaware that they fulfill the diagnostic criteria for chronic migraine. They may self-treat or receive treatment from primary care physicians and/or otolaryngologists with medications for rhinosinusitis, and the chronic migraine goes undiagnosed.³¹

Other sinus-related conditions that are often considered to induce headache are not sufficiently validated as causes of headache. These include deviation of nasal septum, hypertrophy of turbinates, atrophy of sinus membranes, and mucosal contact.^{1,32} The location of pain experienced may often provide clues as to which of the sinuses is primarily involved. For example, maxillary sinusitis may cause infraorbital or cheek discomfort, ethmoid rhinosinusitis may cause tenderness over the lacrimal region, frontal sinusitis characteristically causes pain in the forehead over the orbits, and pain due to sphenoid sinusitis radiates to the occiput and vertex areas.³³ Box 10-3 is a listing of painful disorders of the nose and paranasal sinus complex.

Salivary glands

There are three pairs of major salivary glands: the parotid, submandibular, and sublingual glands. The sensory innervation to the parotid gland is supplied by the auriculotemporal branch of the trigeminal nerve, while the secretory fibers are derived from the glossopharyngeal nerve but transported via the auriculotemporal nerve as well. Both the submandibular and sublingual glands derive their sensory nerve supply from the lingual nerve, while the secretory fibers are derived from the chorda tympani.³⁴ Pain originating in the salivary glands is typically inflammatory, infectious, traumatic, or neoplastic in origin. Common salivary gland disorders that are accompanied by pain include sialadenitis, sialolithiasis, epidemic parotitis, and tumors. Diagnosis of salivary gland pain is usually not difficult due to accompanying signs or symptoms.²⁷ For example, in salivary gland duct blockage or infection, the patient often presents with moderate to severe pain occurring with eating in conjunction with swelling and tenderness of the affected gland. Purulent exudate associated with fever and malaise may occur as well. Other clinical signs include a raised earlobe in the case of a parotid swelling, redness of the overlying skin, lymphadenopathy, and warmth of the overlying skin. Sublingual gland swellings present with a raised floor of the mouth along with obstruction or swelling of the sublingual caruncle.³⁵ First-bite syndrome is diagnosed when patients experience excruciating pain in the ipsilateral parotid gland region at the first bite of each meal, but this pain improves with subsequent mastication. This is thought to be due to parotid gland sympathetic denervation from surgery with resultant hypersensitivity to parasympathetic impulses. There is no consensus on the best treatment for first-bite syndrome, although symptoms tend to improve with time.³⁶

Throat

The throat, or pharynx, is divided into the nasopharynx, oropharynx, and hypopharynx. The sensory supply to the pharyngeal tissues is via branches of the glossopharyngeal and vagus nerves.³⁷ Because of the significant overlap of innervations to these structures, throat pain is often poorly localized, and pain referral to the ear is common.¹⁹ Painful disorders of the throat can be developmental, infectious, inflammatory, neuropathic, or neoplastic in origin.³⁸ Box 10-4 contains a list of the most common painful throat disorders.

Pain Stemming from Systemic Diseases

Oromandibular dystonia

Oromandibular dystonia is an uncommon motor disorder that may contribute to orofacial pain. It is one form of focal dystonia that affects the orofacial region and involves the jaw-opening muscles (lateral pterygoids and anterior digastrics), tongue muscles, facial muscles (especially orbicularis oris and buccinator), and platysma. Dystonia is characterized by an involuntary, repetitive, sustained muscle contraction. The sustained contraction results in an abnormal posturing of a structure and subsequent pain.^{39,40} Oromandibular dystonias are often disabling and affect patients' overall quality of life with pain, difficulty chewing food, speech difficulty, drooling, and social embarrassment.⁴¹

Multiple sclerosis

Multiple sclerosis (MS) is a systemic inflammatory autoimmune disease that is characterized by demyelinating lesions and plaques within the central nervous system (CNS). Although the etiology and pathogenesis of MS remain unclear, the current literature illustrates that the cause

Box 10-4 Head and facial pain arising from the throat

Primary pain

- Laryngopharyngeal reflux
- Allergic rhinitis with postnasal drip
- Chronic mouth breathing
- Foreign body
- Muscle tension dysphonia
- Vocal cord granuloma
- Mucositis
- Granulomatous diseases (rheumatoid arthritis, gout)
- Pemphigus
- Kawasaki disease
- Glossopharyngeal neuralgia
- Tumors
- Viral pharyngitis
- Influenza
- Mononucleosis
- Nonstreptococcal bacterial pharyngotonsillitis
- Streptococcal pharyngitis
- Peritonsillar abscess
- Tonsillitis
- Candidiasis
- Deep space neck infection (retropharyngeal/parapharyngeal space infection)
- Epiglottitis/supraglottitis

Referred pain

- Temporomandibular disorders
- Myofascial pain
- Gastroesophageal reflux disease
- Cardiac pain

of MS is multifactorial and includes genetic predisposition together with environmental factors such as exposure to infectious agents, vitamin deficiencies, and smoking. These agents are able to trigger a cascade of events in the immune system that lead to neuronal cell death accompanied by nerve demyelination and neuronal dysfunction.⁴² The onset of MS symptoms is most often during the third to fourth decade

of life, with an average age of onset of 30 years. This is younger than that of trigeminal neuralgia (TN), which has an average age of onset of between 50 and 70 years.⁴³ In patients with MS, TN occurs at approximately 20 times the prevalence of that in the general population and is usually due to lesions in the intrapontine trigeminal tract or root-entry zone.^{44,45} In MS, up to 31% of TN is bilateral, a rate much higher than TN in the non-MS population.³¹ Treatment of TN pain in MS patients is similar to that in non-MS patients with TN (see chapter 6).

Lyme disease

Lyme disease is a multisystem infection caused by the tick-borne spirochete *Borrelia burgdorferi*. The systemic dissemination of spirochetes from the site of the tick bite may result in a characteristic red rash called *erythema migrans*. The systemic infection primarily involves three extracutaneous organ systems: the heart, most commonly causing otherwise unexplained conduction block; the joints, causing arthralgia; and the nervous system, typically much later in infection. Only 10% to 15% of patients develop symptomatic nervous system involvement, which may present as cranial neuropathy, painful radiculopathy, or lymphocytic meningitis.⁴⁶ The most common manifestation of nervous system infection in both Europe and the United States is cranial nerve involvement—most often facial nerve palsy, which is reported in 5% to 8% of early-stage untreated patients. The disorder itself is indistinguishable from Bell palsy in other circumstances, except that in Lyme disease it can be bilateral in up to 20% to 25% of affected individuals. Although 80% of Lyme-associated cranial nerve palsies affect the facial nerve, other nerves can be involved. Involvement of nerves supplying the extraocular muscles (III, IV, VI) can cause diplopia. Involvement of the fifth nerve can cause hypoesthesia or pain and headaches; seventh nerve involvement can result in hearing changes or vertigo.^{47,48}

Box 10-5 Clinical features of sleep bruxism***Self-report from patient or sleep partner***Sleep*

- Sleep partner complains of grinding noise (occasionally tapping noise with oromandibular myoclonus)

Waking in the morning

- Patient reports jaw muscle discomfort or fatigue
- Temporal headache of short duration
- Difficulty in jaw opening, jaw stiffness, temporomandibular joint noise
- Tooth hypersensitivity to cold stimuli (eg, food, beverage, or air)

Clinical observations*Visual inspection*

- Tooth wear, fracture, and cervical defects
- Tongue indentation

Digital palpation

- Masseter muscle hypertrophy during voluntary clenching (bilateral)
- Jaw muscle tenderness (masseter, temporalis) and temporomandibular joint pain

Miscellaneous

- Dental restoration failure or fracture (eg, crown, denture, inlay, implant)
- Occlusal trauma
- Tongue biting (observed in oromandibular myoclonus)

*Adapted with permission from Kato and Lavigne.⁶³

Bruxism

A recent international consensus position paper defined *bruxism* as a repetitive jaw-muscle activity characterized by clenching or grinding of the teeth and/or by bracing or thrusting of the mandible. Bruxism has two distinct circadian manifestations: it can occur during sleep (sleep bruxism) or during wakefulness (awake bruxism).⁴⁹ Awake bruxism is characterized by tooth clenching during waking hours. Although awake bruxism is a distinctive entity to sleep bruxism, there appears to be considerable overlap in some individuals.⁵⁰ Based on the limited scientific evidence, it appears that the pathophysiology of awake bruxism may be related to the limbic portion of the basal ganglia.⁵¹ It may be viewed as a response to stress or anxiety and affects 20% of the population.^{35,52}

The prevalence of sleep bruxism is estimated by subjective grinding noises during sleep and is reported to be 5% to 8% in adults, 10% to 20% in children, and 3% in the elderly.^{53–56} Risk factors for sleep brux-

ism include smoking, caffeine intake, use of illicit drugs, sleep-disordered breathing, and anxiety.^{57–62} Patients with sleep bruxism may present with numerous clinical features based on self-report, partner report, and clinical observations (Box 10-5). Most sleep bruxism episodes (82%) occur in non-rapid eye movement sleep, predominantly in stages 1 and 2 of sleep.⁶⁴ Studies looking at the physiologic events involving sleep bruxism reveal a cascade of events involving autonomic sympathetic cardiac activation leading to microarousal prior to sleep bruxism episodes. This cascade of events includes temporary increases in sympathetic tone, heart rate, α and δ electroencephalogram (EEG) activity, infrahyoid muscle activity, and respiratory activity.^{51–54}

Connective tissue diseases

Connective tissue diseases are the result of systemic autoimmune dysfunction and dysregulation involving one or multiple organs.⁶⁵ This section discusses more common connec-

tive tissue diseases such as systemic lupus erythematosus, rheumatoid arthritis, Sjögren syndrome, and systemic sclerosis. Other less common connective tissue diseases such as dermatomyositis, polymyositis, and mixed connective tissue diseases may also contribute to orofacial pain and dysfunction.⁶⁵

Systemic lupus erythematosus

Systemic lupus erythematosus is a multiorgan connective tissue disease related to abnormal production of autoantibodies, multisystem inflammation, and vasculopathy. The Systemic Lupus Collaborating Clinics' classification for diagnosis of systemic lupus erythematosus consists of 17 criteria, of which at least 4 must be met, including at least 1 clinical criterion and 1 immunologic criterion. Clinical criteria include but are not limited to the presence of a rash, oral ulcers, or synovitis (in at least two joints), and immunologic criteria include but are not limited to elevated antinuclear antibodies (ANAs), lupus anticoagulant, or low complement. Alternatively, biopsy-proven lupus nephritis in the presence of ANAs or anti-double-stranded DNA (anti-dsDNA) antibodies may be used.⁶⁶ TMJ pain, locking, and crepitation have been reported in systemic lupus erythematosus patients. Similarly, trigeminal neuropathy has been reported to develop as an initial presentation or gradually with this disease.⁶⁵

Rheumatoid arthritis

Rheumatoid arthritis is a chronic, systemic inflammatory disease in which proinflammatory cytokines destroy articular cartilage and subchondral bone.⁶⁵ The diagnosis of rheumatoid arthritis is based on the American College of Rheumatology/European League Against Rheumatism classification criteria, and there are updated guidelines for its treatment.⁶⁷ Half of rheumatoid arthritis patients have TMJ pain and swelling, jaw stiffness, and limited mouth opening.⁶⁸ However, involvement of the TMJ typically occurs later in this disease process than

other joints, so TMJ pain as the initial presentation of rheumatoid arthritis is rare.⁶⁹ Fibrous and bony ankylosis may occur with disease progression.⁷⁰ Imaging of the TMJ with computed tomography (CT) or magnetic resonance imaging (MRI) scans may reveal joint effusion, synovial proliferation, marrow edema, altered disc morphology and displacement, and condylar abnormalities, namely erosions, flattening, sclerosis, subchondral cysts, and osteophytes.^{71,72} Class II malocclusion involving heavy posterior contacts and anterior open bite occur in advanced cases of condylar destruction.⁷³

Sjögren syndrome

Sjögren syndrome is characterized by chronic inflammation of exocrine glands, principally affecting the lacrimal and salivary glands. The decrease in exocrine secretions is caused by autoreactive lymphocytic infiltrates replacing epithelium, causing keratoconjunctivitis sicca and hyposalivation.⁶⁵ The diagnosis of primary Sjögren syndrome is based on the 2016 American College of Rheumatology/European League Against Rheumatism classification criteria based on the weighted sum of five items: anti-Sjögren-syndrome-related antigen A antibody positivity and focal lymphocytic sialadenitis with a focus score of ≥ 1 foci/4 mm², each scoring 3; an abnormal ocular staining score of ≥ 5 (or van Bijsterveld score of ≥ 4); a Schirmer test result of ≤ 5 mm/5 min; and an unstimulated salivary flow rate of ≤ 0.1 mL/min, each scoring 1. Patients who have a total score of ≥ 4 along with signs and symptoms of Sjögren syndrome would fulfill the criteria.⁷⁴

Peripheral neuropathy including trigeminal neuropathy characterized by facial numbness and paresthesia has been reported.^{75,76} Signs of TMDs such as jaw joint sounds, tenderness of the masticatory muscles, and limited range of jaw movement were more common in Sjögren syndrome.⁷⁷ Similarly, the prevalence of headache was 78.1% among Sjögren syndrome patients, with migraine (54%) and

tension-type headache (24.1%) being the most common types.⁷⁸

Systemic sclerosis

Systemic sclerosis is characterized by abnormal fibrosis and subsequent damage and dysfunction of the skin, vasculature, and internal organs.⁶⁵ Microstomia secondary to limited mouth opening from fibrosis is a known orofacial manifestation.^{79–81} The diagnosis of systemic sclerosis is based on the joint 2013 classification criteria of the American College of Rheumatology and the European League Against Rheumatism. Essentially, the diagnosis of systemic sclerosis may be established based on skin thickening of the fingers extending proximal to the metacarpophalangeal joints. Alternatively, seven additive items of varying weights may apply, including skin thickening of the fingers, fingertip lesions, telangiectasia, abnormal nailfold capillaries, interstitial lung disease or pulmonary arterial hypertension, Raynaud phenomenon, and disease-related autoantibodies.⁸² TMJ pain and swelling secondary to synovitis have been noted among systemic sclerosis patients.⁸³ Patients with systemic sclerosis often complain of muscle pain with chewing, headache, and difficulty with mouth opening.⁸⁴ Erosion of the coronoid process, condyle, angle of the mandible, and ramus may also be noted on radiographs.^{63,85,86} Trigeminal neuropathy involving pain and sensory loss has been reported, as have symptoms consistent with trigeminal neuralgia.^{87,88} There are also reports of giant cell arteritis (GCA) in patients with systemic sclerosis.⁸⁹

Fibromyalgia

Fibromyalgia is a pain disorder likely neurogenic in origin presenting as chronic widespread allodynia and/or hyperalgesia. It is postulated that *fibromyalgia* may in fact be a misnomer as it merely represents the severe end of the chronic widespread pain spectrum. There is also debate on whether individuals

diagnosed with fibromyalgia or chronic widespread pain need to be classified as such, as both conditions are treated similarly.⁹⁰ Although its pathophysiology remains an enigma, it is purportedly related to peripheral nerve damage as a result of oxidative stress and mitochondrial dysfunction and inflammation.⁹¹ Also, abnormal processing of the peripheral stimuli within the CNS is thought to be involved.⁹² Its common symptoms include pain for at least 3 months involving the right and left side of the body, above and below the waist, and in the axial skeleton, associated with fatigue and sleep disturbances.⁹³ Other related symptoms include tenderness, stiffness, anxiety, depression, and cognitive obscurity. The most common comorbidities for fibromyalgia are mood and anxiety disorders. Other comorbid conditions include irritable bowel syndrome, tension-type headache, migraine, interstitial cystitis, prostatic pain, vulvodynia, chronic pelvic pain, and TMDs.⁹⁴ Current clinical diagnostic criteria for fibromyalgia from the American College of Rheumatology exclude counting tender points as previously required.⁹⁵

There have been numerous studies suggesting a relationship between TMDs and fibromyalgia. Up to 75% of fibromyalgia patients present with signs and symptoms consistent with TMDs.⁹⁶ One study showed that 53% of fibromyalgia patients reported face pain, of which 71% fulfilled the Research Diagnostic Criteria for TMDs.⁹⁷ Practitioners treating orofacial pain patients should inquire about pains in other areas of the body to exclude fibromyalgia as an etiology.

Lymphatic system

The lymphatic system is composed of an extensive network of small lymphatic capillaries, larger lymphatic vessels, and lymph nodes. The lymphatic system functions as a supplementary drainage system that collects interstitial fluid, protein, and cells and returns them to

circulation. In the head and neck, lymph nodes are grouped into chains, located both within subcutaneous tissues and in deeper tissues associated with muscle and fascial planes. The lymph chains include the occipital, preauricular, postauricular, parotid, buccal, mandibular, submandibular, submental, superficial cervical, internal jugular, spinal accessory, and supraclavicular lymph nodes.

In health, lymph nodes generally are not palpable. *Lymphadenopathy*, which is an alteration in lymph node size, number, and consistency, may indicate pathology, possibly due to a drug reaction, infection, immunologic disorder, or malignancy.^{98,99} Infective causes may be local or systemic and include bacterial, fungal, and viral disease. Inflammatory lymphadenopathy may also be of a noninfective nature from disorders such as sarcoidosis or connective tissue disease. Neoplastic enlargement can be due to primary lymph node disease or metastatic disease.

In the head and neck, the most common node to be enlarged is the jugulodigastric node, secondary to a viral upper respiratory tract infection.⁷⁶ This node is located just inferior and anterior to the angle of the mandible. Solitary enlarged nodes are generally due to a local or regional problem, while multiple enlarged nodes suggest systemic disease. Enlarged nodes that are soft, freely movable, and tender are likely inflammatory. Nodes that are greater than 1 cm, firm or rubbery, fixed to underlying tissue, or matted together and nontender are likely neoplastic. If a cervical lymph node is noted to be greater than 2 cm, the potential for malignancy increases significantly. This risk increases substantially if the cervical lymph node is greater than 3 cm in diameter.¹⁰⁰ The differential diagnoses of non-painful lymphadenopathies include Hodgkin lymphoma, non-Hodgkin lymphoma, leukemia, and plasmacytoma. Most pain disorders associated with the lymphatic system occur secondary to a regional acute inflammatory process (Box 10-6).

Blood vessels

Vascular disease may be a source of head and facial pain (Box 10-7). Orofacial pain is a common presenting symptom of GCA (also known as *temporal arteritis*), a condition caused by granulomatous inflammation of the temporal artery or other branches of the aortic arch. It is found predominantly in people over the age of 50 years, often in the seventh and eighth decade of life. There appears to be an association between GCA and polymyalgia rheumatica, an inflammatory rheumatic condition that affects individuals over age 50 years. Temporal artery biopsies of polymyalgia rheumatica patients without clinical characteristics of GCA showed expression of cytokines (inflammation) without overt vasculitis.¹⁰¹ GCA is characterized by a swollen, tender superficial temporal artery, headache, hip and shoulder girdle pain, and constitutional symptoms.¹⁰² A prominent feature of the disease is jaw claudication characterized as an aching cramp in the masseter or temporalis muscles produced by jaw function. Another feature of the disease is an erythrocyte sedimentation rate of at least 40 mm/h as well as an elevated C-reactive protein level; the C-reactive protein level is a more sensitive marker than the erythrocyte sedimentation rate.¹⁰³ The combination of elevated erythrocyte sedimentation rate and C-reactive protein resulted in improved specificity compared with either test alone; however, neither test is superior to the temporal artery biopsy to establish the diagnosis.¹⁰⁴ The most serious aspect of this disease is blindness that can occur due to inflammation of the posterior ciliary arteries with anterior ischemic optic neuropathy; therefore, immediate referral to the hospital is necessary.⁷⁸ This disorder can easily be confused with TMDs, and prompt, definitive diagnosis via a long-segment temporal artery biopsy is necessary.¹⁰⁵ Treatment involves prednisolone, 60 to 80 mg daily for 4 to 6 weeks and then gradually tapered as symptoms improve over 12 to 24 months.¹⁰⁶

Box 10-6 Etiology of head and neck lymphadenopathy***I. Infectious diseases**

- **Viral:** Infectious mononucleosis (Epstein-Barr virus, cytomegalovirus), infectious hepatitis, herpes simplex, human herpes virus 6, varicella zoster virus, rubella, measles, adenovirus, human immunodeficiency virus
- **Bacterial:** *Streptococcus*, *staphylococcus*, cat-scratch disease, brucellosis, tularemia, chancroid, tuberculosis, atypical mycobacterial infection, primary and secondary syphilis, diphtheria, leprosy
- **Fungal:** Histoplasmosis, coccidioidomycosis, paracoccidioidomycosis
- **Chlamydial:** Lymphogranuloma venereum, trachoma
- **Parasitic:** Toxoplasmosis, leishmaniasis, trypanosomiasis, filariasis
- **Rickettsial:** Scrub typhus, rickettsialpox

II. Immunologic diseases

- Rheumatoid arthritis
- Mixed connective tissue disease
- Systemic lupus erythematosus
- Dermatomyositis
- Sjögren syndrome
- Serum sickness
- Drug hypersensitivity
- Primary biliary cirrhosis
- Graft-vs-host disease
- Silicone-associated
- Periodic fever, aphthous stomatitis, pharyngitis, cervical adenitis (PFAPA)

III. Malignant diseases

- Hematologic (Hodgkin or non-Hodgkin lymphoma, acute lymphoblastic leukemia, chronic lymphoblastic leukemia, hairy cell leukemia, malignant histiocytosis, T-cell lymphoma, multiple myeloma with amyloidosis)
- Metastatic from primary sites

IV. Lipid storage disease

- Gaucher
- Niemann-Pick
- Tangier

V. Endocrine disease

- Hyperthyroid
- Adrenal insufficiency
- Thyroiditis

VI. Other disorders

- Castleman disease (giant lymph node hyperplasia)
- Sarcoidosis
- Dermatopathic lymphadenitis
- Lymphomatoid granulomatosis
- Kikuchi disease (histiocytic necrotizing lymphadenitis)
- Kawasaki disease (mucocutaneous lymph node syndrome)
- Histiocytosis X
- Severe hypertriglyceridemia

*Adapted with permission from Parisi and Glick.⁹⁹

Box 10-7 Head and facial pain arising from blood vessels**Primary pain**

- Subarachnoid hemorrhage (IHS 6.2.2)
- Unruptured vascular malformation (IHS 6.3)
- Saccular aneurysm (IHS 6.3.1)
- Arteriovenous malformation (IHS 6.3.2)
- Giant cell arteritis (IHS 6.4.1)
- Primary intracranial angiitis (IHS 6.4.2)
- Systemic lupus erythematosus (IHS 6.4.3)
- Carotid or vertebral artery dissection (IHS 6.5.1)
- Postcarotid endarterectomy (IHS 6.5.2)
- Cerebral venous thrombosis (IHS 6.6)
- Arterial hypertension (IHS 10.3)

Vertebral artery syndrome (ICD-10 G45.0)

Vertebral artery (VA) involvement can contribute to various cervicogenic headaches. Syndromes with similar symptoms include VA compression syndrome (ICD-10 M47.12), vertebral basilar syndrome (ICD-10 G45.0), and benign paroxysmal positional vertigo (ICD-10 H81.13). The major extracranial region of the vertebral artery is protected by the vertebral canal and the surrounding soft tissue structures; however, there is vulnerability from the second cervical vertebrae to the foramen magnum. Vertebral artery injury in the suboccipital region can occur from severe cervical spine trauma, such as a fracture of the atlas, whereas compression may exist in the presence of Barré-Liéou syndrome.¹⁰⁷ Red flags immediately necessitate further testing to rule out vertebral artery involvement; these include disorientation, nausea, vomiting, visual disturbances, dizziness, or vertigo that occur simply by changing from a non-weight-bearing (supine) position to a weight-bearing position (ie, sitting or standing).^{73,108–111} An experienced physician or physical therapist should perform the assessment, which can be curtailed in favor of neurologic and radiologic testing if any of the above red flags reoccur or intensify during the evaluative process. Active cervical spine range of movement and provocation testing into positions of rotation, side-bending, and extension can be used to stretch, narrow, or kink the ipsilateral and/or contralateral VA; however, this must be performed with great caution, and the reliability is questionable unless performed by an experienced clinician.^{73–76} The delineation between labyrinthine and VA involvement should also be considered. The trained dentist can auscultate the carotid and subclavian arteries for bruits with the patient in a seated position and the head in neutral, but further testing in positions of cervical rotation and extension to each side should be designated to others.⁷³

Barré-Liéou Syndrome (ICD-10 M53.0)

Irritation of the vertebral artery or posterior cervical sympathetic network via stretching or compression forces can give rise to Barré-Liéou syndrome, which is also known as *posterior cervical sympathetic syndrome*.⁷⁷ This rare syndrome, characterized by intracranial vasoconstriction, may cause widespread facial and cranial symptomatology that can mimic migraine, tension-type headache, sinusitis, and craniofacial dysautonomia, given the involvement of the trigeminal spinal tract, upper cervical roots, posterior sympathetic fibers, and vertebral artery. Head and neck pain that falls into the Barré-Liéou category is usually continuous but variable with qualitative characteristics that consist of throbbing, burning, stinging, or pinching sensation.^{77,112,113} Tinnitus, decreased auditory perception, a feeling of dust in the eye, blurred vision, tearing, nasal irritation, and hoarseness may also exist. One or more of these symptoms, in addition to pain, may become evident or exacerbated by active range of movement or positional or manual suboccipital testing techniques, primarily indicative of vertebral artery testing. It is imperative that any positive findings be further evaluated by a definitive neurologic examination. This syndrome is very controversial as it may simply fall into the category of a vertebral artery syndrome associated with other compressive forces within the suboccipital fossa.⁷⁹

Other systemic causes of head and facial pain

There are many systemic diseases and disorders that are accompanied by headache or facial pain. Included among these are metabolic and endocrine disorders, infectious disease, autoimmune disease, cardiovascular disease, renal disease, and pulmonary disease. Box 10-8 lists some of the more common

Box 10-8 Head and facial pain arising from systemic disease

- Anemia
- Adrenal insufficiency
- Arthritides
 - Rheumatoid arthritis
 - Osteoarthritis
 - Psoriatic arthritis
 - Systemic lupus erythematosus
- Chronic pulmonary failure with hypercapnia
- Diabetes mellitus
- Fibromyalgia
- Hashimoto thyroiditis
- Herpes zoster
- HIV/AIDS
- Hypertension/pheochromocytoma
- Infectious mononucleosis
- Ischemic heart disease
- Lyme disease
- Menopause
- Menstruation
- Metastatic malignancies
- Multiple sclerosis
- Primary malignancies
- Renal failure (uremia)/dialysis

of these systemic diseases. It is beyond the scope of this chapter to discuss these many entities; however, the practitioner should remain alert to include systemic disease in a differential diagnosis when facial pain is accompanied by systemic signs or symptoms.^{47,114} Symptoms that may suggest systemic disease are listed in Box 10-9.^{115,116} In these instances, head or facial pain is merely an accompanying symptom of a potentially serious underlying disease, and the clinician must guard against the trap of attempting to treat the facial pain when a much more serious underlying problem is present.^{117,118} In these situations, referral to the appropriate health clinician must be considered. In addition to these disorders, the reader is referred to chapter 4 for a discussion of other worrisome constitutional symptoms.

Box 10-9 Signs or symptoms suggestive of systemic disease

- Chest pain
- Chronic fatigue
- Extreme hunger or thirst
- Fever
- Generalized aches and pains
- Malaise
- Palpitations
- Shortness of breath
- Skin lesions
- Tachycardia
- Unintentional weight loss or gain

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11

Sleep and Orofacial Pain

Key Points

- ◇ The impact of chronic pain on sleep can be described as a vicious cycle with mutual deleterious influences causing an increase in pain and disrupted sleep.
- ◇ The role of the clinician is to identify orofacial pain patients complaining of poor sleep and refer them to a sleep laboratory for further evaluation of a suspected concomitant sleep disorder.
- ◇ Sleep hygiene advice and cognitive behavioral treatments or short-term use of medication may help restore sleep quality.
- ◇ Management of pain and sleep needs to be customized to each patient based on his or her psychosocial and medical history.

Approximately one-third of patients with temporomandibular disorders (TMDs) or other conditions that manifest orofacial pain report poor sleep quality or unrefreshed feelings on awakening. The impact of chronic pain on sleep can be described as a vicious cycle with mutual deleterious influences between pain and disrupted sleep. Several quantitative sleep variables (eg, total sleep time, slow-wave sleep, sleep stage duration, sleep arousal, presence of disordered breathing events, and periodic limb movements during sleep) characterize the pain-related disruption of sleep. The role of the clinician is to identify patients complaining of poor sleep. First, it is necessary to exclude the role of concomitant musculoskeletal pain, neuropathic pain, or comorbid conditions (eg, complaints related to fatigue, depression, and anxiety). Clinicians should then refer the patients to a sleep laboratory for further evaluation of a suspected sleep disorder, such as insomnia (*ICD-10* G47.0), sleep

apnea (*ICD-10* G47.3), or periodic limb movements (*ICD-10* G47.61). The aim of this chapter is to provide an overview of the current understanding of pain and sleep interactions and to discuss evidence-based and empirical knowledge to help clinicians recognize, diagnose, and manage poor sleep in patients with chronic orofacial pain conditions.

Sleep Overview

Sleep is a natural physiologic activity that is essential for good quality of life and species survival. Most animals totally deprived from sleep become sick from infection or organic dysfunctions within a few weeks. Sleep is vital for recovery from fatigue, memory consolidation, heart and muscle tissue repair, and brain function at cellular and network levels. Its duration is variable from individual to individual. Most human adults sleep between 6 and 9 hours per night; below or above this range, individuals tend to report more pain.^{1,2} Adolescents tend to have an irregular circadian sleep schedule (*ICD-10* G47.23) that may predispose them to some pains. Without enough sleep, humans tend to be less functional and to report cognitive problems, mood alterations, immune dysfunction, and somatic pain-related complaints within 3 to 4 days.^{3,4}

Sleep and wakefulness are under the regulation of a circadian process that lasts approximately 24 hours. Typically, sleep and wake cycles are regulated by an oscillatory behavior at the level of the hypothalamus suprachiasmatic nucleus in the higher regions of the central nervous system (CNS). Human sleep and wake rhythms are tuned by the sun and moon (ie, 24-hour light and dark cycle) as well as by external cues like sounds.^{5,6}

It is important to understand circadian rhythms because pain patients may have a circadian phase mismatch that could explain their symptoms. A person who goes to sleep later every night may have a hard time waking up

early. This sleep cycle is called *circadian phase delayed* (*ICD-10* G47.21). Conversely, a person who goes to sleep earlier every day may wake up earlier (*circadian phase advanced* [*ICD-10* G47.22]).^{2,7} Some gene expressions (eg, a tandem-repeat polymorphism in the coding region of the 5-repeat allele of the clock gene *PER3* 5/5 [period circadian protein homolog 3]) may explain vulnerability to sleep loss as cognitive frontal cortex dysfunction.^{8,9} The role of circadian rhythm-related genes on cognitive function and fatigue is an area of ongoing investigation. The outcomes of this research may also provide better understanding of the interaction between chronic pain and sleep.

Sleep is divided into rapid eye movement (REM) and non-REM (NREM) sleep. During a typical night, there are three to five NREM to REM cycles, termed the *ultradian rhythm cycle*, in contrast to the 24-hour circadian cycle that is under the sun and moon time schedule. NREM sleep is further divided into *light sleep* (stages N1 and N2) and *deep sleep* (N3, formerly called *stages 3 and 4*), which is dominated by slow-wave brain activity (Fig 11-1). REM sleep is often called *paradoxical sleep* because the CNS and the autonomic nervous system are highly active while all skeletal muscles are in a hypotonic state, as if the body were paralyzed.⁵

In healthy adults, the majority of body movements (eg, of limbs and jaws) tend to occur in light sleep, more specifically in relation to sleep stage shifts, such as from deeper to lighter sleep or from any stage toward REM sleep. The occurrence of movements is periodic during sleep and follows a cyclic pattern. Every 20 to 40 seconds, sleep oscillates from quiet periods to more active ones. The active physiologic periods, lasting 3 to 15 seconds, are called *arousals*; in healthy individuals, these tend to reappear 7 to 15 times per hour of sleep. Such active periods are windows where the sleeping individual can readjust his or her body position, reset body temperature, and, if any harmful event is perceived, become

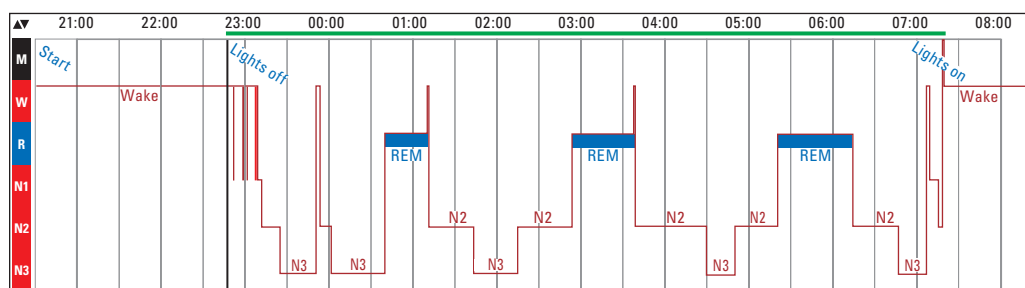


Fig 11-1 Normal hypnogram of a 50-year-old man, showing three complete sleep cycles. Registration began at 20:30 and finished at 8:30. Analysis time (green line) is shown from the time lights were turned off until they were turned back on. M, movement time; W, wake time; R, REM time. (Courtesy of Dr D. M. Laman, Department of Clinical Neurophysiology, Onze Lieve Vrouwe Gasthuis [OLVG], Amsterdam, The Netherlands.)

fully awake (ie, a fight-or-flight reaction could be triggered).

About 50% to 80% of sleep bruxism (*ICD-10* G47.63) events (ie, repetitive jaw-muscle contractions with or without tooth grinding) are observed during recurrent arousal periods. A method has been developed to monitor such a cyclic alternating pattern (CAP) during sleep. CAP comprises an active phase A that is subdivided into three periods: A1 (dominated by slow-wave brain activity, which preserves sleep), A2 (the transition period between A1 and A3), and A3 (the period dominated by arousal).¹⁰ Phase B of a CAP is the quiet period of sleep. Sleep bruxism seems to occur preferentially in CAP A2 and especially in A3, thereby providing a physiologic window to facilitate the onset of rhythmic movements during sleep.¹¹ It is important to understand that sleep bruxism tends to occur in association with sleep-stage transitions and when arousal pressure is greater.

Patients with chronic pain and more specifically fibromyalgia (ie, chronic widespread pain) tend to present with 50% more phase A2 and A3 periods than healthy individuals.¹⁰ In contrast, during normal healthy adult sleep, nociception is partially attenuated to preserve sleep continuity. Stages N1 and N2 have higher threshold and lower response rates to noxious stimuli than wakefulness, and stage N3

has even higher thresholds, while thresholds vary during REM sleep.^{1,10,12} Sleep is associated with a partial physiologic deafferentation of sensory (ie, afferent) inputs into the CNS, and there is reduced neuronal activity at the thalamocortical network level with brief and transient reactivation of neural pathways from the brainstem to the cortex during arousal.^{6,10,12}

Normal adults usually fall asleep within 20 to 30 minutes of their going to bed. Insomnia may be suspected when sleep onset is longer than 20 to 30 minutes, occurring three to five times a week, or if spontaneous awakening is present during the night without the ability to resume sleeping.^{7,13} About 10% of the general population suffers from chronic insomnia, but the prevalence is reported to be around 30% in chronic pain patients.¹

Pain conditions can alter normal sleep patterns. The effect of acute pain on sleep seems to follow a linear model: Pain precedes poor sleep (ie, cause-and-effect sequence), and sleep returns to normal when the acute pain is resolved. However, a circular model seems to predominate in the presence of chronic pain (ie, pain lasting for at least 3 months). In the circular model, a night of poor sleep is followed by a day with complaints of more intense and variable pain, which is then followed by a night of nonrestorative sleep with morning-related complaints of unrefreshing sleep. It is impor-

tant to note that the circular model cannot be generalized to all patients; some may follow a linear model even with chronic pain.^{1,14}

Interactions Between Pain and Sleep

Approximately one- to two-thirds of chronic musculoskeletal pain patients report poor sleep quality.¹ *Nonrestorative sleep* is defined as an unrefreshed feeling on awakening, and it is present in about 10% of the general population, with a higher risk as individuals age. Nonrestorative sleep is a frequent complaint found in shift workers who work during the night, in patients who sleep more than 9 hours per night, and in those with insomnia-related symptoms or with fatigue and mood alterations.^{1,3} The presence of *restorative sleep* (ie, sleep that leaves the individual feeling refreshed, rested, and reenergized) appears to predict the resolution of chronic widespread pain in some individuals.¹⁵ It remains to be demonstrated whether some individuals are genetically protected against the deleterious impact of chronic pain on sleep.^{1,14}

The sleep of orofacial pain and TMD patients can often be nonrestorative or of poor quality; such complaints are mostly reported in the morning on awakening.^{16,17} Approximately 36% of TMD patients experience insomnia, and 28% experience sleep apnea.¹⁶ Patients suffering from trigeminal neuralgia or orofacial neuropathic pain also report waking episodes during their sleep.¹⁸ About 7% to 10% of adults report frequent pain in the jaw muscles, and TMD patients with muscle pain tend to report their symptoms mostly in the afternoon, similar to delayed-onset muscle soreness.¹⁷ Common features or potential risk factors for TMD patients in addition to disturbed sleep include fatigue, depression, somatization, anxiety, and daytime tooth clenching.^{19–22}

The frequently assumed association between TMD pain and sleep bruxism was re-

cently revisited. In a cohort of female myofascial TMD patients and pain-free controls who agreed to sleep in a laboratory for two consecutive nights, no relationship was found between pain and the number and intensity of jaw-muscle contractions related to sleep bruxism.²³ However, the TMD patients showed more respiratory effort-related arousals (RERAs) and higher jaw-muscle tone over the course of the night.^{24,25} This suggests that TMD patients may have a propensity to keep a type of hyperarousal level during the entire night; in other words, like insomnia patients and contrary to good sleepers, they are not able to wind down.^{26,27} Further, factors like trait anxiety and an imbalance in the autonomic cardiac activity during sleep may be concomitant associated factors.^{28,29} Despite these recent insights, the etiology of poor sleep in TMD patients requires further investigation. It is important for the clinician to identify if transient jaw muscle pain in the morning is isolated or if it is secondary to sleep bruxism and/or sleep apnea, because the management strategies will differ.^{15,17,22,30,31} Most evidence supporting a link between orofacial pain and sleep is derived from questionnaire studies; final translation to clinical application requires further validation from sleep laboratory or home ambulatory recordings.^{32,33}

Comorbidities

Various factors may contribute to the interaction between pain and poor sleep: Lifestyle, beliefs, difficulties in coping with anxiety, poor physical fitness, and chronic fatigue may be risk factors for insomnia, a condition found in 36% of patients with TMD.^{14,16} In addition, sleep comorbidities like periodic limb movements and sleep-disordered breathing (apnea/hypopnea or upper airway resistance) can exacerbate the interaction between pain and poor sleep (Fig 11-2). Periodic limb movements and sleep apnea/hypopnea have been reported in both TMD and chronic widespread pain/

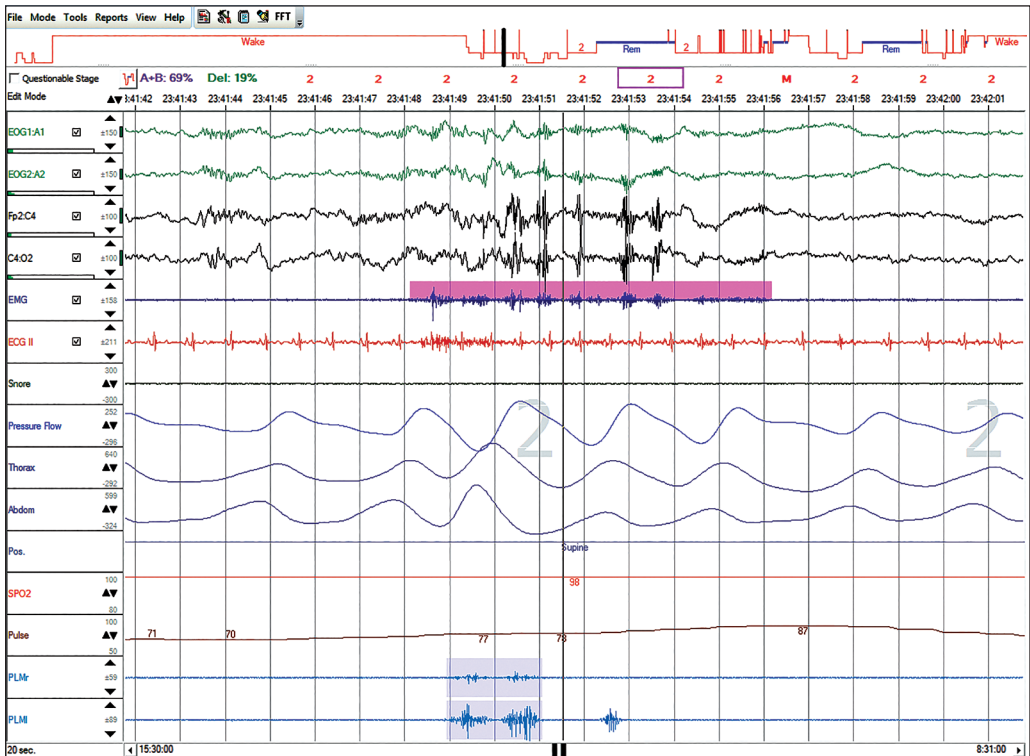


Fig 11-2 Example of a 20-second page of a polysomnographic recording. On top is the hypnogram of the total registration time. The *thick black line* represents the 20-second epoch shown in the rest of the image. On the left side are the various recording channels: EOG, eye movements (1, left; 2, right); FP2:C4 and C4:O2, long-distance electroencephalogram (EEG) channels from front to back on the right side; EMG, electromyogram of the chin/jaw; ECG, electrocardiogram (electrodes placed near Erb's point, above the clavicle); snore, channel of the snore sensor; pressure flow, air flow sensor; thorax and abdomen, thoracic and abdominal respiratory effort sensors channels; Pos, sleep position (in this case, supine); SPO₂, oxygen saturation measured at the fingertip; pulse, pulse rate; PLMr and PLMI, leg movements (right and left). An 8-second event of repetitive jaw-muscle activities is shown in the EMG (chin/jaw) channel (*pink area*) and in the EEG channels. At the same time or slightly before, the EEG shows signs of arousal (more fast activity), the respiration deepens and becomes more pronounced, the pulse increases, and independently, some repetitive leg movements lasting less than 1 second following the start of the arousal are shown in the PLM channels. (Courtesy of Dr D. M. Laman, Department of Clinical Neurophysiology, Onze Lieve Vrouwe Gasthuis [OLVG], Amsterdam, The Netherlands.)

fibromyalgia patients with greater frequency than in controls.^{16,34} A periodic limb movement index over 10 events per hour of sleep (from an electromyogram of the tibialis leg muscle) is the new lower threshold for a polysomnographic diagnosis for periodic limb movements.¹³ Sleep apnea/hypopnea is diagnosed if there are at least 5 events per hour of sleep in adults or 1 to 2 per hour of sleep in children,

while no clear consensus has been reached yet for adolescents.¹³

Compared with adult patients without chronic widespread pain, patients with chronic widespread pain have a higher risk (odds ratio > 3) of reporting comorbid conditions such as fatigue, headache, gastrointestinal problems, and sleep disturbances.³⁵ Orofacial pain patients also report more problems in coping

Box 11-1 Elements for assessment of orofacial pain and sleep complaints

- Identify the nature of the pain and sleep complaints. Ask the patient to keep a 24-hour diary, if possible, to monitor periods of pain exacerbation, time and duration of daily naps, sleep time, and wake time.
- Review medication type and dose, time of intake, and use of other treatments for pain or sleep complaints, such as physical therapy or cognitive behavioral therapy.
- Identify mood alterations (eg, depression, anxiety).
- Identify stressful life events or traumatic events.
- Identify poor sleep behavior or hygiene (eg, irregular sleep schedule; disrupted sleep environment; frequent use of caffeine, alcohol, or medications that alter sleep).
- Identify the extent of fatigue and/or sleepiness (eg, falling asleep easily during daily activities or while watching TV, driving-related sleepiness) using the Epworth Sleepiness Scale.*
- Identify the risk of sleep-disordered breathing using the STOP-Bang or Berlin questionnaire.[†]
- Assess the risk of insomnia (ie, more than 20 to 30 minutes' delay in falling asleep, depending on nap habits, or difficulty resuming sleep after awakening during the night).
- Assess the presence of any periodic limb movements (eg, leg kicks that will increase sleep fragmentation above a cumulative threshold of events per hour of sleep).
- Assess if any snoring, alone or with sleep-disordered breathing (RERA upper airway resistance) or apnea/hypopnea (ie, cessation of breathing with reduced oxygenation with concomitant sleepiness), may contribute to increased sleep fragmentation and poor sleep quality complaints.
- Identify clinical risk factors associated with sleep-related breathing disorders, such as retrognathia, a deep and narrow palate and narrow arch, a large tongue, and large tonsils and adenoids.

*The Epworth Sleepiness Scale is an easy-to-use screening questionnaire to guide the clinician on the extent of daytime sleepiness; scores over 10 to 12 are suggestive of a sleep-related disorder and warrant medical evaluation.⁴¹

[†]The STOP-Bang or Berlin sleep questionnaire may help the clinician discern between simple snoring and sleep apnea^{42,43}; see also the recent review on use of sleep questionnaires for TMD patients.⁴⁰

with fatigue, psychologic distress, headaches, and abdominal pains.^{16,21,36,37} Patients in a family medical practice who had hypertension, pain syndromes (eg, back pain, arthritis), and depression also had more sleep disturbance-related complaints.³⁸ Several sleep-related problems, such as sleepiness, dozing off during daily activity, frequent awakenings during the night, complaints related to restless legs syndrome (ie, the awake symptoms that occur in approximately 80% of periodic limb movement cases), and signs of sleep-related breathing disturbances (eg, loud snoring and cessation of breathing suggestive of apnea)

were higher in pain patients.^{1,7,15} Likewise, a recent large-scale US-based case-control study reported a high likelihood of self-reported obstructive sleep apnea being associated with higher odds of chronic TMD (odds ratio > 3).³⁹ While this is an important finding, the absence of polysomnographic confirmation of sleep-disordered breathing calls for a careful interpretation.⁴⁰

Importantly, clinicians should recognize and understand the influences of the above-described sleep comorbidities on the differential diagnoses and treatment planning for their orofacial pain patients (Box 11-1).

Box 11-2 Management of sleep-related disturbances in orofacial pain patients*

- | | |
|---|--|
| <ul style="list-style-type: none"> • Review the patient's sleep hygiene to provide basic empirical advice on features such as: <ul style="list-style-type: none"> – Wake-sleep cycle (eg, regular bedtime and awakening schedule) – Sleep environment (eg, dark, cool, quiet bedroom; if the partner snores, use of ear plugs or sleeping in a different room may help) – Lifestyle habits (eg, avoidance of intense exercise, coffee, smoking, alcohol, and intense or troubling discussions 3 to 6 hours before sleep) • Advise the patient on the benefits of regular mild exercise (eg, walking). • Consider the benefits of physical therapy and CBT. | <ul style="list-style-type: none"> • Consider short-term pharmacologic methods: <ul style="list-style-type: none"> – Analgesics alone or combined with muscle relaxants (eg, methocarbamol) or with sleep aids (eg, diphenhydramine) – Muscle relaxants or sedatives (eg, cyclobenzaprine, temazepam) – Hypnotics or antidepressants (eg, zolpidem, trazodone, amitriptyline, duloxetine) – Other medications (eg, gabapentin, pregabalin) • Consider the possibility of complementary medicine approaches (eg, yoga, meditation, valerian, lavender). • Consider oral appliances for patients with snoring and/or obstructive sleep apnea and sleep bruxism. • If there is any evidence of sleepiness with sleep apnea/hypopnea or other medical conditions, arrange a consultation with a specialist in sleep medicine. |
|---|--|

*Low on evidence for sleep and TMDs.

Management of Orofacial Pain and Related Sleep Disturbances

Box 11-2 outlines how to approach management of sleep-related disturbances in orofacial pain patients.^{1,15} Cognitive behavioral therapy (CBT) has been used to aid in the management of pain conditions as well as sleep disturbances. The type of CBT known to improve pain is different than CBT used to manage insomnia or poor sleep behavior. It seems logical that merging both pain and insomnia CBT methods might yield the best results, but to date there have not been enough studies supporting CBT use in patients suffering from both orofacial pain and poor sleep or insomnia.⁴⁴

Manual therapies (ie, physical approaches) are frequently suggested to patients for pain and sleep management, but their benefit

seems to be variable; indeed, a lack of evidence currently prevents the drawing of any conclusion on the benefits of manual treatment approaches. A recent randomized controlled trial failed to demonstrate any benefit from progressive muscle relaxation and sleep hygiene measures on sleep bruxism.⁴⁵ Mild analgesics (most are available over the counter) are commonly used alone or in combination with a muscle relaxant or sleep inducer, but this practice is also not yet based on good evidence for orofacial pain conditions. Due to a heightened risk of respiratory depression, opioid use in the evening is contraindicated for patients with sleep-disordered breathing; such patients need to take advantage of treatment involving a mandibular advancement appliance (MAA), continuous positive airway pressure (CPAP), or bilevel positive airway pressure (BiPAP).¹ Duloxetine, a selective serotonin and norepinephrine reuptake inhibitor, reduces

pain in chronic widespread pain/fibromyalgia patients with slight improvement in sleep quality. More established medications, such as tricyclic antidepressants (eg, amitriptyline or trazodone), have mild to moderate positive effects on both pain and sleep. Gabapentin, pregabalin, and sodium oxybate also appear to improve pain and sleep quality and continuity. However, it is important to know that none of these medications, with the exception of duloxetine, have approval from the US Food and Drug Administration for the combination of sleep and pain management. Their use is thus off-label, and clinicians prescribing such medications must take responsibility for such use. Respiratory devices (eg, MAA and CPAP) may

help patients with chronic fibromyalgia and/or morning headaches.^{46,47} However, randomized controlled clinical studies on orofacial pain patients are needed before conclusions can be drawn about the benefits and safety of such approaches in the general population.

Overall, chronic orofacial pain can be associated with disrupted sleep. Clinicians need to identify orofacial pain patients complaining of poor sleep and refer them to a sleep laboratory for further evaluation. Based on the individual patient's unique psychosocial and medical history, pain and sleep management strategies, including sleep hygiene recommendations, cognitive behavioral treatments, or short-term use of medication, need to be customized.

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Axis II: Biobehavioral Considerations

12

Key Points

- ◇ The biobehavioral model of pain is the foundation for clinical assessment and pain management.
- ◇ Core biobehavioral principles include multifactorial assessment; the role of learning patient history; and the interplay between biologic, psychologic, and social factors.
- ◇ It is necessary to screen for biobehavioral risk factors including pain, distress, and pain-related disability as well as pain history. Be sure to note red and yellow flags for patient care.
- ◇ A comprehensive evaluation of biobehavioral factors includes pain location and intensity, pain-related disability, psychologic distress, sleep dysfunction, posttraumatic stress disorder (PTSD), alcohol or drug abuse, limitations in use and movement of structures associated with orofacial pain conditions including the temporomandibular joint (TMJ) and masticatory muscles, and parafunctional activities.
- ◇ The most common psychiatric disorders encountered in the orofacial pain practice include depression, anxiety, PTSD, somatic symptom disorders, and personality disorders.
- ◇ Following referral to mental health care providers, the clinician should expect a comprehensive evaluation, a treatment plan targeting skills acquisition, and feedback, which should all be provided in a timely manner.
- ◇ The standard of care is integrated care among health care professionals.

Foundation of the Biobehavioral Model

Scientific advances have been made in understanding modulatory control of ascending and descending neural circuits involved in pain processing, including the role of glial cells and gut microbiome influences on neural functioning. Variables such as emotion, cognition (including attention and expectation), and behavior are now understood to play very important roles in pain transmission, awareness, and suffering. Because emotions, cognitions, and behaviors can facilitate or inhibit orofacial pain, it is necessary to adopt a biobehavioral model of disease. Behavioral factors encompass a broad spectrum of behavioral science theory and techniques for change. Examples of behavioral science theory include principles of learning, cognitions and memory, interpersonal processes, family systems, and social learning; techniques for change may be relaxation training, interpersonal psychotherapy, biofeedback, cognitive therapy, and breathing training. When behavioral factors are discussed in the context of how they contribute to the functioning of biologic systems, it is appropriate to use the term *biobehavioral*.

As discussed in chapter 1, Engel¹ noted that the biomedical model, with its focus on pathobiology, does not fully explain the development of disease states. Therefore, he introduced the term *biopsychosocial* to describe the complex interactions between biology, psychologic states, and social conditions that bring about and/or maintain function or dysfunction. The term *biobehavioral* is parallel to the word *biomedical*, and both concepts are subsumed in Engel's biopsychosocial model. While the term *biopsychosocial* is often used because it is more globally accepted, *biobehavioral* calls attention to behavioral factors as they contribute to the functioning of biologic systems.

Adopting the biobehavioral model of orofacial pain requires that linear, unidirectional

models of causation and of treatment be replaced with a bidirectional approach to understanding disease etiology and delivering treatment. Whether the practitioner provides dental or psychologic treatment, a mechanistic linear model (eg, identify the cause, treat the cause, observe recovery) for understanding orofacial pain conditions is an incomplete model that will yield incomplete, inappropriate, and misdirected clinical care. Unless behavioral, psychologic, and social dimensions of a patient's presenting complaints and current adaptive strategies are addressed in the treatment plan, effective management of the pain condition will likely not be achieved, especially in chronic pain conditions. This multidisciplinary philosophy of treatment does not necessarily require a multispecialty clinic with dentists, psychologists, physical therapists, and physicians; it rather requires individual practitioners themselves to possess a worldview that embraces the biobehavioral perspective. From there, appropriate integration of diverse treatment strategies can be implemented instantaneously as patient circumstances, the symptom picture, and the case conceptualization evolve over the course of treatment as well as over the course of the disorder.

Pain is a complex phenomenon influenced by multiple biologic, psychologic, and social factors. The sensation of pain is evoked when nociception reaches thalamocortical-basal ganglia circuitry in the brain; however, because pain is a personalized perceptual experience, it can be modified by factors other than the intensity of the nociceptive stimuli themselves. For example, excitatory factors that could amplify the pain experience include fear, anxiety, attention, and expectations of pain. Conversely, reports of pain may reduce as a result of self-confidence, positive emotional states, relaxation, and belief that the pain is manageable.² Importantly, these modifying factors not only affect the perceptual aspects of what defines *pain* at any moment for an individual; they also contribute to descending

modulation. These examples highlight the concept that nociception is the result of a dynamic balance between peripheral input and ongoing central nervous system (CNS) regulation of that input at the level of the dorsal horn entry into the CNS.

The biobehavioral approach to orofacial pain disorders involves assessing not only the underlying behavioral and psychologic disturbances but also the physiologic disturbances that may be associated with the pain condition. The patient may need to learn new skills for managing these disturbances and should be able to rely on his or her care provider for help. The need for skill acquisition can range from simple to complex, and the latter may involve referral to a mental health care professional. Effective symptom management, both physical and psychologic, may be elusive for many patients, especially those whose pain has become chronic (ie, lasting longer than 3 to 6 months). These patients may have adopted coping patterns to maintain some level of functioning, but their efforts should be assessed by the clinician to ensure they remain in the patient's best interest. Certain coping strategies, while perhaps successful in the early stage of an illness, may eventually contribute to the development of maladaptive patterns that extend beyond the pain condition and into multiple aspects of daily life. For example, a patient who stops engaging in pleasurable daily activities because of pain upon movement may be prone to depression. When maladaptive patterns emerge, it is important that the clinician be prepared to recognize and manage them appropriately, because failure to do so will likely prolong suffering (ie, an individual's negative emotional reaction to pain) and prevent effective symptom management. It is also possible that maladaptive coping patterns were in practice before the onset of the pain condition and may have intensified the problem. Such coping patterns may also be associated with a variety of psychopathologic conditions (these are discussed in later sections

of this chapter). The psychopathology may be actively preexisting, it may be subclinical until the onset of an intractable problem, or it may be emergent in response to a new illness.

The biobehavioral perspective introduces a model whereby the assessment process includes an interview component that focuses not only on the biologic aspects of the presenting condition but also on the psychosocial processes, thus providing a broader perspective from which to understand and conceptualize treatment for a patient's presenting pain symptoms. It is rare that pain reports are based solely on psychologic or so-called *psychogenic factors*.³ It is equally rare, however, to find that pain—especially chronic pain of at least 3 to 6 months' duration—is not influenced by psychologic and social factors to some degree. Such factors may also account for the individual differences in response to similar levels of pain. Because there can be substantial individual variability in response to painful conditions and a variety of social factors (eg, modeling, litigation, compensation), the reported intensity of pain may not necessarily be linked to an individual's expressed reaction to the pain. It is common for both clinicians and patients to be confused regarding the relative nature of reported pain intensities; one reaction is to dismiss such reports as "subjective" (often with the intended meaning of *irrelevant* or *imaginary*). The relative nature of pain intensity does not diminish its validity; rather, it requires the clinician's active interpretation to make it meaningful. In short, it is the task of the clinician to understand the patient's story and to make sense of his or her pain reports.

For many chronic pain conditions, it may be difficult to predict treatment outcomes without knowing the full psychosocial history of the patient. Learning to manage one's orofacial pain conditions for extended periods of time can help patients considerably, but ongoing biobehavioral issues may either promote or prevent the use of such skills for symptom management, leading to the common pattern

of remission–relapse. The reality is that “curing” pain is often not a viable clinical treatment goal, whereas learning to manage pain with the physical and psychologic tools developed and refined through the practice of science can be a viable goal. A major long-term goal is finding the dynamic balance of input and CNS control at the dorsal horn level. Stress reactivity is one of the factors that often contribute to relapse and can be one of the most difficult skills to master. To prevent relapse as a result of stress, patients should work toward experiential understanding of *allostasis*, another example of a dynamic balance among systems.

In recognition of these complexities, Dworkin et al^{4–7} proposed several models for capturing the dimensions of pain over time. Inherent in these models is the simultaneous consideration of both the physical status and the biobehavioral status for every patient. For assessment of both types of status to be equally useful in the clinic, reliable assessment methods are needed for the physical examination (using an operationalized framework) and the biobehavioral screening (using standardized, validated instruments). Extensive research has demonstrated the value of these core components in terms of clinical trials and modeling disease progression and response to treatment.^{8–11} The current versions of diagnostic and biobehavioral assessments are emerging from structured assessments for which reliability and validity has been previously demonstrated.^{8,12–15} A recent development has been the Orofacial Pain: Prospective Evaluation and Risk Assessment (OPPERA) studies that place due recognition on the genetic underpinnings of neuroplasticity, on biobehavioral factors, and on their interactions in shaping risk for developing a pain disorder.^{16–35} A primary overarching conclusion from the OPPERA studies is that temporomandibular disorders (TMDs) are seldom a simple localized condition and are far more often a result of complex multiple risk determinants.³⁶ Consistent with that conclusion, the biobehav-

ioral model for the clinical care of patients with pain disorders is intended to encompass all aspects of neurobiology associated with health and disease. For example, when patients tell their doctors that they are depressed, they are informing them of the state of their brain and how the resultant behavior is recursively further shaping that brain state. Assuming that reliable and valid methods are used for the assessment, this type of information gathered via self-report instruments and interviews is no less valuable than that obtained from a clinical examination.

Implementing a Biobehavioral Framework: Dual-Axis Coding

A multiaxial nosology has been created, implemented, and refined on a broad scale to recognize behavioral and psychologic dimensions in the etiology of orofacial pain disorders. Similar to the development of axial coding systems for psychiatric disorders created by the American Psychiatric Association³⁷ and pain disorders developed by the International Association for the Study of Pain, the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) were developed by a group of scientists and clinicians in 1992.³⁸ Axis I focuses on the physical nature of the disease and includes the variety of orofacial pain conditions discussed in earlier chapters of this text. Axis II focuses on the patient’s adaptation to the pain experience and pain-related disability that may result from the pain itself. It also uses standardized and validated methods to assess the extent to which the orofacial pain condition is associated with psychologic distress, disability, or impairment in functioning (ie, significant disruption in normal activities) (Table 12-1).

The RDC/TMD Axis II was an attempt to codify the emotional sequelae and functional limitations that accompany chronic orofacial pain conditions and to determine whether there is a need to refer patients to additional

Table 12-1 Axis II assessment instruments

| Domain | Instrument | No. of items | Level of screening |
|---|--------------------------------|--------------|--------------------|
| Based on DC/TMD recommendations | | | |
| Pain location | Pain manikin drawing | 1 | UB, B, C |
| Pain intensity | GCPS | 3 | UB, B, C |
| Pain disability | GCPS | 4 | UB, B, C |
| Distress | PHQ-4 | 4 | UB, B |
| | PHQ-9 Depression | 9 | C |
| | GAD-7 Anxiety | 7 | C |
| Physical symptoms | PHQ-15 | 15 | C |
| Limitation | JFLS | 8 or 20 | B (8), C (20) |
| Parafunction | OBC | 21 | B, C |
| Other instruments for pain-relevant constructs | | | |
| Sleep | Pittsburgh Sleep Quality Index | 18 | C |
| | PROMIS | 43 | C |
| PTSD | PTSD Checklist | 17 | C |
| Alcohol use | AUDIT-C | 3 | C |
| Stress | Perceived Stress Scale | 10 | C |

AUDIT-C, Alcohol Use Disorders Identification Test; B, brief; C, comprehensive; DC/TMD, Diagnostic Criteria for Temporomandibular Disorders; GAD, generalized anxiety disorder; GCPS, graded chronic pain scale; JFLS, jaw functional limitation scale; OBC, oral behaviors checklist; PHQ, Patient Health Questionnaire; PROMIS, Patient-Reported Outcome Measures Information System; UB, ultra brief.

providers. Psychiatrists or clinical psychologists may perform a formal assessment of cognitive, emotional, and behavioral sources of disruption in normal functioning due to or associated with the pain problem. This coding system was refined with the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) project to update the RDC/TMD, but the two-axis coding strategy has remained a central feature of the nosological framework.^{38,39}

In 2010, an international consensus workshop¹² agreed on the minimal basic components that should be assessed for a sufficient biobehavioral evaluation: pain, physical function, overuse behaviors, comorbid physical symptoms, and emotional and psychosocial function. Another workshop⁴⁰ clarified the distinction between what is needed for initial screening, what is needed for more comprehensive assessment in a clinical setting, and

what might be of value in a specialist biobehavioral setting. Ongoing workshops sponsored by the International RDC/TMD Consortium (now known as InFORM) continue to develop Axis II assessment strategies.

It is the responsibility of the clinician to judge the level of complexity of the patient's clinical presentation and to decide whether the treatment plan should include additional resources outside the scope of the dental practice. The task is not to develop a psychiatric diagnosis (eg, major depression secondary to the loss of a spouse) but to develop a treatment plan that includes appropriate care for the unique features of the presenting patient. There are various self-report instruments that have demonstrated reliability and validity in identifying potential psychologic dysfunction that can interfere with pain management from the physical medicine perspective, and

these can be used to augment the screening. Standardized instruments provide the clinician with an actuarial approach to decision making. This will ensure more information is gathered than the limited amount provided by the initial interview and prevent inherent clinician-based personal biases from clouding clinical judgments. Health care providers can have difficulty in making accurate judgments of the psychologic status of pain patients and may tend to overreport psychopathology.^{41,42} The results of these studies suggest that the use of screening instruments may help improve the accuracy of clinical decision making in the orofacial pain setting.

Brief Screening for Biobehavioral Factors

It is necessary for clinicians to conduct an assessment of biobehavioral factors in the initial consultation session.^{39,43–45} In terms of which factors should be evaluated, the degree of the assessment should depend on the setting (eg, general dental or medical office, orofacial pain specialist office, research clinic, psychologist office) and purpose (eg, initial screening, more in-depth evaluation by the orofacial pain specialist, comprehensive evaluation by a consulting psychologist) of the evaluation. The selection of the level of the biobehavioral focus implies that the clinician understands the importance of biobehavioral factors in the patient's presentation and the context in which the patient evaluations occur. When it comes to the first line of screening, however, the critical dimensions include (1) some means of assessing multiple pain conditions or complaints in addition to the orofacial pain that generated the initial clinical visit, (2) pain intensity and pain-related disability, and (3) psychologic distress.^{8,14,44,46,47}

One of the strongest and most consistent predictors of the onset of a new orofacial pain condition is the presence of other ongoing

pain complaints.³⁶ Multiple pain conditions also appear to be a strong predictor of the transition from acute pain to chronic pain. Presence of multiple pain complaints can be assessed with a drawing of the full human body (*pain manikin*), front and back, where the patient can note areas of ongoing pain. Other initial strategies for assessing multiple pain conditions include using a checklist or specific questions concerning pain in other regions of the body.

Both the intensity of pain and the impact of the pain on functioning can be obtained with the Graded Chronic Pain Scale (GCPS).⁴⁸ This brief, eight-item screening instrument includes an assessment of number of pain days in the last 6 months; current pain intensity, worst pain intensity, and average pain intensity using a scale of 0 to 10 (where 0 represents "no pain" and 10 represents "pain as bad as can be"); and four questions concerning disability related to the pain. When averaged together, the pain intensity items provide an excellent overall index of pain intensity. Based on the intensity and disability ratings, patients can be classified into one of five categories, grades 0 to IV. Grade 0 represents being pain free, grade I represents low intensity of pain and low disability, grade II represents high intensity of pain and low disability, grade III represents moderately limiting disability, and grade IV represents severely limiting disability. Pain intensity is not considered in grades III and IV because poor functional status, as represented by the disability grade, becomes substantially more important than pain intensity. The GCPS is recommended for regular use in the orofacial pain setting because it is a reliable, valid, and brief screening tool for pain and pain-related disability. High self-rated levels of pain, interference, and impact, along with low ability to control pain, suggest the need for further biobehavioral evaluation and appropriate referral for consultation.^{48,49}

The more common forms of distress presenting in the orofacial pain clinic include depression and anxiety, ranging from mild

symptoms to severe disorders.⁴⁹ Depression and anxiety are described in detail in later sections of this chapter to provide a broader understanding of these conditions within the context of the orofacial pain setting. However, the immediate concern of the clinician is to screen patients and identify those who need further consultation and care by a qualified mental health care provider. While there are a variety of screening instruments, a very brief measure for screening distress is the Patient Health Questionnaire four-item (PHQ-4),⁵⁰ which assesses both depression and anxiety. The PHQ-4 evaluates functioning over the past 2 weeks with a scale ranging from 0, meaning “not at all” to 3, meaning “nearly every day.” It requires about 1 minute for administration. This brief instrument yields a rating of normal, mild, moderate, or severe distress. Any nonnormal rating is an indication for further evaluation by a qualified mental health care provider. This instrument is ideally suited for the screening of distress in the orofacial pain environment.

Several other standardized screening questionnaires are available for depression and anxiety that can enable the clinician to make informed decisions about the need for more extensive diagnostic decision making and treatment planning.^{51–53} In clinical settings, the choice of one instrument over another is far less important than knowing the instrument and knowing the distribution of scores in one’s clinical population. The Jaw Functional Limitation Scale (JFLS) has been recommended as a primary assessment tool for evaluating the impact of pain on core functions of the masticatory system.⁵⁴ The JFLS may be administered as a 20-item instrument yielding three subscales (masticatory limitation, jaw mobility limitation, and verbal and emotional expressiveness limitation) or as an eight-item global limitation scale.

The information obtained from the patient should be consistent with any physical diagnosis, and when it is not, other questions should

be raised in the clinical interview. For example, reported severe limitation in both mastication and jaw mobility simultaneous with minimal clinical signs may point toward catastrophizing or symptom amplification, or it may point toward an incomplete understanding of what has happened to the patient. In contrast, minimal limitation despite severe reported pain and significant clinical signs may indicate a patient who is trying to overcompensate. Assessment instruments also provide important functional evidence in situations when the provider must demonstrate treatment efficacy.

The clinician should consider whether the screening assessment should also address oral behaviors. The Oral Behaviors Checklist (OBC)^{55,56} is a 21-item scale that was developed during the DC/TMD validation study to identify common oral behaviors associated with TMDs. This scale provides the clinician with a patient’s perspective on a broad sample of oral behaviors (eg, chewing gum, clenching teeth, pressing tongue forcibly against teeth) that may influence orofacial pain. It has demonstrated acceptable validity and reliability for the measurement of oral behaviors over time.

While this brief comprehensive screening battery (ie, the pain manikin, GCPS, PHQ-4, JFLS, and OBC) provides the clinician with initial data to guide case conceptualization and treatment planning, there may be circumstances where there is not sufficient time or resources to use all of these measures. In these cases, it is recommended to at least perform an ultra-brief screening comprising the pain manikin, GCPS, and PHQ-4.

Comprehensive Evaluation of Biobehavioral Factors

In addition to depression and anxiety, studies have identified the important roles of sleep disturbances, somatic awareness, perceived stress, and PTSD as strong predictors of distress and pain in orofacial pain

Box 12-1 Red and yellow flags for referral of orofacial pain patients**Red flag: Refer immediately**

- Suicidal thoughts or plans

Yellow flag: Proceed with caution and consider referral

- Alcohol or drug use
- Persistent beliefs about pain
- Illness behaviors
- Problems in compensation or claims
- Time off work
- Problems at work
- Overprotection from family members
- Lack of social support
- Chronicity of pain
- Functional limitations
- Discrepancies in findings
- Overuse of medications
- Inappropriate behavior, expectations, or responsiveness to prior treatment

patients.^{23–25,29,33,36,56–59} There are brief, reliable paper-and-pencil screening instruments available to assess sleep (eg, Pittsburgh Sleep Quality Index, Patient-Reported Outcome Measures Information System sleep instruments), somatic awareness (90-item Symptom Check List Revised [SCL-90-R], Pennebaker Inventory of Limbic Languidness), perceived stress (Perceived Stress Scale), and PTSD (PTSD checklist). Moreover, clinicians may use the PHQ-9 for a more detailed screening for depression, the Generalized Anxiety Disorder 7 (GAD-7) for anxiety, and the PHQ-15 for an evaluation of physical symptoms.

Many clinicians may find the information from these instruments helpful in the processes of evaluation and treatment planning. Overall, it is important that dentists and other health care clinicians be able to recognize maladaptive coping mechanisms and direct patients to appropriate evaluation and treatment programs to address these dysfunctions.

Stressful life events, such as conflicts in home or work relationships, financial problems, and cultural readjustment may contribute to illness and chronic pain.^{60,61} Environmental stressors may heighten tensions, insecurities, and dysphoric affects that may in turn lead to increased adverse loading (clenching or grinding) of the masticatory system as stress is converted to muscle tension and increased parafunctional behavior.⁶² Stressors will not always lead to increases in muscle tension, and increases in muscle tension will not always create pain, but it is a distinct possibility to consider when evaluating an individual's clinical presentation. The use of a pain manikin, the GCPS, and the PHQ-4 serves as an acceptable initial minimum screening for all orofacial pain patients to determine if they should be referred for further evaluation by qualified mental health care providers.

In addition to pain-relevant biobehavioral constructs, Turner and Dworkin⁴⁴ noted the value in screening for prolonged and/or excessive use of opiate medications, benzodiazepines, alcohol, and other addictive medications. Clinicians can screen for these problems in the course of their initial evaluation interview. When screening for alcohol use, one reliable instrument is the Alcohol Use Disorders Identification Test (AUDIT-C).⁶³ This three-item questionnaire is a reliable means of identifying whether an individual should be referred for careful evaluation of alcohol abuse.

Health care providers working with patients with chronic back pain use a strategy in the initial evaluation process to identify red and yellow flags: *Red flags* are those representing a potentially serious condition for which immediate attention is needed, and *yellow flags* represent potential psychologic or social barriers to full recovery (Box 12-1). Clinicians in the orofacial pain setting should also use a red and yellow flag identification strategy when implementing a biobehavioral approach. Red flags in the psychosocial history of the orofacial pain patient demand immediate attention; these primarily focus on signs of suicide. The

most common signs of potential suicide include talking about suicide, either generally or specifically, and/or actual plans for taking one's own life (suicidal ideation) and hopelessness. There are other warning signs for suicide, including persistent and despairing mood, significant weight loss or gain, change in appetite, withdrawal and social isolation, and change in sleep pattern—all symptoms that are associated with depression as well. Any patient who presents with thoughts about suicide, plans for suicide, or hopelessness should be evaluated for risk assessment as soon as possible by qualified mental health care professionals.

Yellow flags for treatment may include persistent beliefs about pain, illness behaviors, problems in compensation/claims, time off from work, problems at work, overprotection from family members, or lack of social support. Additional factors include chronicity of pain, functional limitations, discrepancy in findings, overuse of medication, inappropriate behavior (often including items from the first list, but not exclusively), inappropriate expectations, and inappropriate responsiveness to any prior treatment^{40,64} (see Box 12-1). Any of these issues can interfere with treatment, and the orofacial pain specialist needs to be wary of initiating treatment in individuals with these concerns. When possible, a careful and thorough evaluation should be performed by a psychologist, psychiatrist, psychiatric nurse practitioner, or other appropriately trained mental health care provider before treatment begins.

Psychiatric Disorders

Orofacial pain patients, particularly those with a history of significant pain over 3 months in duration, may experience significant psychologic distress that complicates the management of their presenting complaints. A distinction can be drawn between the role of pain psychology and the use of diagnostic psychiatric disorders in a clinical setting for orofacial pain. One

difference is that pain psychology places an emphasis on dimensional assessment rather than classification (diagnosis). Furthermore, pain psychology is interested in the detailed integration of specific domains of functioning known to be important in a pain patient's experience and the incorporation of the biobehavioral domain into the clinical arena and decision making. This approach to patient management focuses on the identification of problem areas that lend themselves to structured, empirically supported therapies (eg, cognitive behavioral therapy) that will facilitate referrals when needed. Pain clinicians will encounter patients whose functioning is severely compromised, and knowing when to refer to a mental health care provider benefits the patient and the clinician alike. The description of mental states provided by the classic psychiatric disorders captures the many ways in which human systems undergo dysregulation. It is essential to recognize these in patients so that the foundations of a dual-axis classification system can be better understood and applied clinically.

Although many mental conditions can be influenced by or result from orofacial pain disorders, only a select group is addressed in this chapter. This section highlights the more common mental disorders that clinicians are likely to encounter; the comprehensive evaluation of psychologic status should be conducted by appropriately trained mental health care providers.⁶⁵ Gatchel et al^{66–68} have reported that the most frequently occurring problems include major depression, anxiety disorders, and personality disorders. The other disorders presented in this chapter have a much lower frequency of occurrence, but orofacial pain clinicians should be aware of them to make a successful referral for definitive diagnosis and treatment. For a description of other mental conditions, the reader is encouraged to review the current *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5)*.³⁷ Each disorder is accompanied by its codes

from the *DSM-5* and/or *The International Classification of Diseases, Tenth Edition (ICD-10)*.

Major depressive disorder (*DSM-5* 296.2x; *ICD-10* F32)³⁷

Major depression has been identified as one of the most common mental disorders occurring in the orofacial pain environment.⁶⁸ Clinical data suggest that almost one-third of patients presenting for treatment of orofacial pain may be experiencing symptoms consistent with a diagnosis of depression.⁶⁹ The diagnosis of major depression requires at least five of the following symptoms over a 2-week period, with at least one of the symptoms being depressed mood or loss of interest/pleasure:

- Depressed mood most of the day
- Decreased interest or pleasure in all or most daily activities
- Weight loss or change in appetite
- Insomnia or hypersomnia
- Daily psychomotor agitation or retardation
- Fatigue or loss of energy
- Feelings of worthlessness or guilt
- Reduced ability to think or concentrate
- Thoughts of death or suicide

When these symptoms cause distress and impair functioning and are not due to a medical condition or substance use, the diagnosis of major depression is likely. Major depression is a serious, potentially life-threatening condition, and referral to appropriate health care providers for effective treatment is essential in addition to care for the pain disorder itself.

Anxiety disorders

Generalized anxiety disorder (*DSM-5* 300.02; *ICD-10* F41.1)³⁷

GAD is diagnosed when an individual has persistent and excessive anxiety or worry for a period of 6 months or longer. The person who

is experiencing GAD is not able to control the feelings of anxiety or worry, and at least three of the following symptoms are present: restlessness, fatigue, difficulty concentrating, irritability, muscle tension, and sleep disturbance. In addition, the symptoms cause significant impairment of interpersonal functioning or work performance, and the anxiety and worry are not associated with another mental disorder (eg, obsessive-compulsive disorder), substance use (drugs or alcohol), or another medical condition. It is estimated that between 10% and 30% of the orofacial pain population may be experiencing GAD.⁶⁸ Anxiety is particularly important to identify during acute phases of a pain disorder because it leads to nonadaptive behaviors, which may promote chronicity.² Referral for treatment of GAD may be delayed based on whether treatment of the orofacial pain condition itself may begin to alter symptoms.

Panic disorder (*DSM-5* 300.01; *ICD-10* F41.0)³⁷

Although much less common than GAD, *panic disorder* involves a sudden, intense onset of fear and terror that is often accompanied by thoughts of impending disaster. It can include chest pain, palpitations, and shortness of breath, which can be so severe that the individuals may feel as though they are dying. Individuals having a panic attack report sensations of choking/smothering and are afraid of losing control of their thoughts. Panic disorder is diagnosed when a panic attack has occurred and when at least one of the following criteria present for at least 1 month: persistent concern about having another attack, worry about the implications or consequences of the attack, and a notable change in behavior related to the attacks or fear thereof. In addition, the panic attacks must not be due to a medical condition or substance use. Even though panic disorder is uncommon, it is a condition that requires immediate attention and coping skills. Therefore, if panic disorder is suspected, appropriate referral should be made immediately.

**Posttraumatic stress disorder (DSM-5 309.81;
ICD-10 F43.1)³⁷**

Considerable professional interest and burgeoning public concern have focused on the sequelae of traumatic experiences. It is now well recognized that physical and sexual abuse are implicated in the etiology of a broad spectrum of physical and emotional symptoms. The essential feature of PTSD is the onset of characteristic symptoms following exposure to a traumatic event either involving direct personal experience or the witnessing of such an event. Traumatic events usually involve actual or threatened death or serious injury or a threat to one's physical and psychologic integrity. Typical symptoms include persistent reexperiencing of the traumatic event, persistent avoidance of stimuli associated with the trauma and numbing of general responsiveness, and persistent symptoms of increased arousal. The full symptom picture must be present for more than 1 month, and the disturbance must cause clinically significant distress or impairment in daily functioning. For children, sexually traumatic events may include developmentally inappropriate sexual experiences without threatened or actual violence or injury. The disorder may be especially severe or long-lasting when the traumatic experience has been created by deliberate human intent (eg, torture or rape) as contrasted with naturally occurring disasters. The likelihood of developing this disorder may increase as the intensity of and physical proximity to the event increases.

Psychologic reexperiencing of the traumatic event may occur in several ways, commonly as recurrent and intrusive recollections, distressing dreams, and, in rare instances, brief dissociative states or flashbacks during which components of the event are relived and the person behaves as though experiencing the event at that moment. Intense psychologic distress or physiologic reactions often occur when the person is exposed to triggering events that resemble or symbolize an aspect

of the traumatic event (eg, entering an elevator for a person who may have been assaulted or raped in an elevator; or any intraoral pain or manipulation for individuals who may have been sexually violated or traumatized in the mouth).

Typically, individuals suffering from this condition make deliberate efforts to avoid thoughts, feelings, or conversations about the traumatic event and, in some instances, may develop amnesia for important aspects of the traumatic experience. Diminished psychologic responsiveness, referred to as *psychic numbing* or *emotional anesthesia*, may be accompanied by markedly diminished interest in previously enjoyed activities and markedly reduced capacity for emotional responsiveness. The individual has persistent symptoms of anxiety or increased arousal that were not present before the trauma; the arousal symptoms are frequently associated with sleep disturbance, nightmares, hypervigilance, and an exaggerated startle response. This increased arousal is often accompanied by activation of the autonomic nervous system as measurable by electrocardiography, electromyography, and sweat gland activity. In younger children, distressing dreams of the event may change into generalized nightmares. Rather than having a sense of reliving the past as a memory, young children often re-create versions of the trauma through repetitive play. For example, a child involved in a motor vehicle accident may reenact scenes of toy cars crashing, or sexually traumatized children may depict genital contact occurring between toy animals.

It should be emphasized that not all psychopathology occurring in individuals exposed to extreme stress should necessarily be attributed to PTSD. Symptoms of avoidance, numbing, and increased arousal that are present before exposure to the stressor require consideration of other diagnostic alternatives (eg, a mood disorder or an anxiety disorder). *Acute stress disorder* is distinguished from PTSD because the symptoms appear and subsequently resolve within 4 weeks of the trauma. *Adjustment dis-*

order is the appropriate diagnosis for situations in which the response to a stressor does not meet the criteria for PTSD or when the stressor itself is not judged to be that threatening.

A significant proportion of orofacial pain patients are likely to meet lifetime criteria for having experienced PTSD.^{58,59} This relatively high rate of occurrence is consistent with other data, suggesting that exposure to traumatic life events is common among orofacial pain patients and patients with other pain conditions as well.^{58,70} It is therefore necessary that clinicians have an awareness of the signs and symptoms of PTSD and are able to make appropriate referrals for treatment. The characteristics of this disorder (ie, autonomic activation, perceptual distortion, and denial of one's own needs) may prevent significant therapeutic gains unless the underlying disorder is addressed.

Substance use disorders (DSM-5 291-305 and ICD-10 F10-19)³⁷

It is not uncommon for patients with orofacial pain to have ongoing or previous substance-related disorders. These disorders include dependence, abuse, intoxication, and withdrawal. *Substance dependence* is defined as a pattern of substance use that leads to clinically significant impairment or distress. The term *substance abuse* refers to a pattern of substance use that has significant negative consequences, such as failure to meet obligations of work, school, or home; behaviors that are physically hazardous like driving a car when impaired; legal problems; or interpersonal problems related to the continued substance use. *Substance intoxication* refers to the reversible signs and symptoms associated with the intake of a substance that can produce physical, behavioral, or psychologic changes. *Withdrawal* refers to substance-specific physical, behavioral, or psychologic changes that occur with the reduction or stoppage of a substance that has been used over a period of time.

Clinicians should also be familiar with the terms *addiction* and *pseudoaddiction*. *Addiction* involves one or more of the following characteristics: impaired control over drug use, compulsive use of drug(s), continued use despite harm, and craving. A person with an addiction often does not take medications according to prescription or schedule, has multiple visits to multiple practitioners, and likely reports on a frequent basis that his or her prescriptions have been lost or stolen. It is important to distinguish addiction from pseudoaddiction in chronic pain patients.^{71,72} *Pseudoaddiction* looks like addiction in that the same behaviors are typically present, but the patient has identifiable nociception (eg, cancer pain, neuropathic pain, postsurgical pain) that is undermedicated, so he or she is in constant search of effective treatment to control the pain. When such a person is given adequate medication, the addiction-like behaviors cease. Distinguishing addiction from pseudoaddiction requires good knowledge of the patient by the clinician and is greatly facilitated by careful history taking, comprehensive and standardized physical examinations, and use of biobehavioral assessment instruments. In the case of pseudoaddiction in particular, progress notes should clearly document the contingent nature of the medication seeking along with the appropriateness of the medication to the identified or suspected nociception.

Substance abuse disorders can occur within broad classes of substances that include alcohol, amphetamines or similar compounds, caffeine, cannabis, cocaine, hallucinogens, inhalants, nicotine, opioids, phencyclidine or similar compounds, and sedatives/hypnotics/anxiolytics. The clinician must be alert to potential abuse disorders and be able to develop a treatment plan that is in the best interests of patients and their health care providers. Unless the clinician has specialty training in the management of addiction disorders, the appropriate standard of care is referral to a health care provider who does have specialty train-

ing. It is important to develop a rapport with patients who have problems with substance abuse to foster successful referral.

Sleep disorders³⁷

Sleep disorders are common in patients with chronic pain, and there are two major sleep disorders that the clinician is likely to encounter: primary insomnia (*DSM-5* 780.52; *ICD-10* F51.0) and breathing-related sleep disorders (eg, sleep apnea, *DSM-5* 327; *ICD-10* G47.3). Other sleep disorders, such as narcolepsy or night terrors, are not as common in the chronic pain environment. *Primary insomnia* involves difficulty in initiating or maintaining sleep, and it must have persisted for at least 1 month. The sleep problem results in distress or difficulties in the individual's life that could include interpersonal or work-related issues. For primary insomnia to be diagnosed, it must be clear that depression, anxiety, or medication/substance use is not contributing to the disruptions in sleep. Primary insomnia can be managed with behavioral medicine strategies playing primary roles.

Breathing-related sleep disorders involve being sleepy or experiencing insomnia as a result of a breathing problem that disrupts regular sleep. The breathing problem is usually the result of either obstructive or central sleep apnea, but it can be the result of central alveolar hypoventilation syndrome. These latter conditions represent medical disorders that merit immediate referral to physicians trained in sleep medicine. Breathing-related sleep disorders require medical evaluation, and biobehavioral approaches should also be considered as appropriate interventions.

Somatic symptom and related disorders³⁷

Clinicians should recognize and appreciate somatic symptom and related disorders because they represent an extremely important group of mental conditions in which the patient reports somatic complaints and yet has no

physical evidence of organic disease. Somatic symptom and related disorders are subdivided into the following categories: somatic symptom disorder, illness anxiety disorder, conversion disorder, factitious disorder, unspecified somatic symptom and related disorders, other specified somatic symptom and related disorders, and psychologic factors affecting other medical conditions.

Somatic symptom disorder (*DSM-5* 300.82; *ICD-10* F45.0)

The essential features of somatic symptom disorder are recurrent and multiple somatic complaints of at least several years' duration for which treatment has been sought and significant disarray or distress in the person's life for which no treatment is sought. Clinical characteristics include preoccupation with somatic complaints, amplification of symptoms, denial of difficulty in life, and a high level of treatment seeking for somatic complaints accompanied by poor adherence and compliance to that treatment. The disorder classically begins before age 30 years and has a chronic but fluctuating course. Historically, this condition was previously referred to as *hysteria* or *Briquet syndrome*, and the history of medicine clearly demonstrates that its presentation is anchored into the current values and beliefs of the host culture.⁷³ Complaints are often presented in a dramatic, vague, or exaggerated manner or are part of a complicated dental and/or medical history in which many physical diagnoses have been considered. The individuals frequently receive dental care from a number of practitioners, sometimes simultaneously. Complaints often extend to multiple organ systems. The term *hypochondriasis* is no longer used in the diagnostic nosology because approximately 75% of hypochondriasis patients match the diagnostic criteria for somatic symptom disorder, while the remaining 25% have elevated levels of anxiety such that they are more appropriately diagnosed with illness anxiety disorder (*DSM-5* 300.7; *ICD-10* F45.21).

To diagnose somatic symptom disorder, there must be a history of the report of somatic symptoms that are distressing, along with thoughts, feelings, and/or behaviors that are out of proportion with the symptoms, and an inordinate amount of time and energy must be devoted to addressing these health concerns. Individuals with this disorder, for example, complain of abdominal bloating and nausea, while vomiting, diarrhea, and food intolerance are less frequent symptoms. It should be emphasized that the unexplained symptoms in somatic symptom disorder are not intentionally feigned or produced.

Because of the highly restrictive character of the required symptom pattern, somatic symptom disorder is not common, but somatization as a style or as a major characteristic about a person is fairly common in the orofacial pain population.⁷⁴ For example, the somatization scale scores on the SCL-90-R have a significant relationship with the number of muscles reported as tender during an RDC/TMD examination.⁷⁵ These clinical data highlight the necessary attention needed to consider somatization as a way of coping among patients in an orofacial pain practice.

Anxiety and depressed mood are common, and suicide threats or attempts; antisocial behavior; and occupational, interpersonal, and marital difficulties frequently accompany somatization. The clinical course is typically chronic but fluctuating in nature and rarely remits spontaneously. Through seeking numerous evaluations, diagnostic tests, and multiple trials on medication and frequently submitting unwittingly to unnecessary surgery, these patients often experience iatrogenic complications both in and out of the hospital.

The differential diagnosis necessitates ruling out physical disorders that present with vague, multiple, and confusing somatic symptoms. In addition, schizophrenia with multiple somatic delusions, dysthymic disorder, GAD, panic disorder, and conversion disorder need to be excluded from this specific diagnostic

classification. Because pathophysiology has yet to be identified, myofascial pain could qualify as a disorder without clear organic pathology for clinicians; according to the description presented here, such a patient would qualify for a diagnosis of at least somatic symptom disorder as a method of coping. Before neuropathic mechanisms were suspected to underlie burning mouth–disorder types of conditions, *somatization* was a diagnostic label unfortunately applied to such individuals for many years. Because many chronic pain disorders do not have obvious pathology responsible for the inferred nociception, distinguishing such functional disorders from somatization is not conceptually simple but is critically important for both the patient and the clinician. These disorders may include non-specific lower back pain and irritable bowel syndrome, for example, and they represent at least a disorder of psychophysiologic dysregulation. The distinction is also not clinically simple, but a comprehensive history and attention to the biobehavioral screening and identified yellow flags (see Box 12-1) are an excellent and essential starting point.

Conversion disorder (functional neurologic symptom disorder) (DSM-5 300.11; ICD-10 F44.x)

Patients with conversion disorder present with a loss of or alteration in physical functioning that suggests a physical disorder but instead is an expression of psychologic conflict or need. The disturbance is not under voluntary control and cannot be explained by any physical disorder or known pathophysiologic mechanism. Conversion disorder is not diagnosed when conversion symptoms are limited to pain (see somatoform pain disorder) or to a circumscribed disturbance in sexual functioning.

Factitious disorder (DSM-5 300.19; ICD-10 F68.1)³⁷

Factitious means not real, genuine, or natural. *Factitious disorders* are therefore characterized by physical and/or psychologic symptoms that are produced by the individual and are

under voluntary control. The judgment that the patient is willfully creating the symptoms is based, in part, on the patient's ability to simulate illness in such a way as to avoid detection. However, such acts also have a compulsive quality because the individual is unable to refrain from a particular behavior even if its dangers are known. These conditions should therefore be considered *voluntary* only in the sense that they are deliberate and purposeful but not in the sense that the patient adopts or sustains the pathologic behavior intentionally. The presence of factitious psychologic or physical symptoms does not preclude the coexistence of true psychologic or physical illness.

Factitious disorder is distinguished from acts of malingering. Whereas in *malingering*, the patient is in pursuit of obvious and recognizable benefits through willful falsification, in a factitious disorder, there is no apparent goal other than to assume the patient role. An act of malingering may be considered adaptive under certain circumstances, but a diagnosis of a factitious disorder implies psychopathology (often a severe personality disturbance). According to the *DSM-5*, malingering is not considered a mental illness.

Unspecified somatic symptom and related disorder (*DSM-5* 300.82; *ICD-10* F45.9)

The essential feature of unspecified somatic symptom and related disorder is one or more physical complaints that persist for 6 months or longer. These symptoms cannot be fully explained either by any known physical condition or by the direct effects of an incident or substance (eg, the effects of injury, substance use, or medication side effects). Alternatively, the physical complaints or resultant impairment are grossly in excess of what would be expected from the history, physical examination, or laboratory findings. The symptoms must cause clinically significant distress or impairment in social, occupational, or other areas of adaptive functioning. This is a residual category for those persistent somatoform pre-

sentations that do not meet the full criteria for other somatic symptom disorders.

Psychologic factors affecting other medical conditions (*DSM-5* 316; *ICD-10* F54)³⁷

When the primary presenting complaint is a medical (ie, physical) condition influenced by one or more psychologic or behavioral issues, psychologic factors affecting other medical conditions can be diagnosed. Typically, the diagnosis will link the psychologically related issues with the physical condition, as in the example, "stress and anger toward significant other affecting masticatory muscle pain." The issues identified must be contributing to the disorder by (1) having a close connection in terms of time between the beginning of the physical condition and the onset of the psychologic or behavioral factors, (2) interfering with the treatment of the condition, (3) increasing health risk, or (4) increasing physiologic activation that brings on or intensifies the physical condition.

This diagnostic category provides the practitioner with the means to codify a comorbid psychologic condition that may be contributing to the patient's capacity to manage a medical problem. Because chronic pain complaints represent a complex interaction between psychologic and physiologic factors, the use of this diagnostic category is common. This label also may be more acceptable to some patients than other labels of psychiatric conditions.

Personality disorders³⁷

Generally speaking, a *personality disorder* is a long-term pattern of thinking and acting that is significantly different from that of the general population and results in significant consequences to the individual or those around the individual. These abnormal patterns may manifest as exaggerations or dysfunction of certain dimensions of personality. For example, it is normal to have occasional moments of not trusting another person, but it is abnormal to live with a consistent pattern of suspicious-

Table 12-2 Personality disorders

| Disorder | DSM-5 code | ICD-10 code |
|---|------------|-------------|
| Cluster A: Odd or eccentric disorders | | |
| Paranoid | 301.0 | F60.0 |
| Schizoid | 301.20 | F60.1 |
| Schizotypal | 301.22 | F60.3 |
| Cluster B: Emotional, dramatic, or unpredictable disorders | | |
| Antisocial | 301.71 | F60.2 |
| Borderline | 301.83 | F60.3 |
| Histrionic | 301.50 | F60.4 |
| Narcissistic | 301.81 | F60.81 |
| Cluster C: Anxious and fearful disorders | | |
| Avoidant | 301.82 | F60.6 |
| Dependent | 301.6 | F60.7 |
| Obsessive-compulsive | 301.4 | F60.5 |

ness and mistrust. An orofacial pain condition is most likely to appear after the individual has already been displaying a pattern of thinking and behaving characteristic of a personality disorder. These patterns, however, may or may not have interfered with daily functioning prior to the development of the orofacial pain condition. Recent data suggest that a significant number of orofacial pain patients have coexisting personality disorders.^{67,68}

There are three basic groups of personality disorders that each share common clinical presentations (Table 12-2). *Cluster A* includes odd or eccentric disorders and schizotypal disorders. *Cluster B* includes emotional, dramatic, or unpredictable disorders like antisocial, borderline, or histrionic disorders. *Cluster C* includes anxious and fearful disorders like avoidant, dependent, and obsessive-compulsive disorders.³⁷

Cluster A

Within Cluster A, *paranoid personality disorder* describes an individual who does not trust others and is very suspicious. These patients may

overinterpret what the clinician says or may be unforgiving of others for perceived injury or insult. Patients with *schizoid personality disorder* are detached from others and have very limited emotional expression. A person with this disorder has few, if any, close friends or family and usually does things alone. The *schizotypal personality disorder* shares the features of detachment and limited emotional expression but is also characterized by substantial distortions of thought and very unusual behavior. Thought distortions include magical thinking, belief in telepathy, and weird fantasies. Unusual behaviors might involve acting out the use of “special powers” or listening to “voices for direction.”

Cluster B

Within Cluster B, the *antisocial personality disorder* is characterized by little or no regard for the rights of others. The diagnosis of this personality disorder involves the individual committing crimes, lying, not planning ahead, being irritable and aggressive to the point of getting into fights, disregarding safety for self

and others, being irresponsible, and/or not expressing remorse or sorrow for behavior that hurts others. In short, the antisocial personality disorder involves behavior that is self-centered and does not conform to the general rules and expectations of society.

Borderline personality disorder represents a repeated pattern of instability of relationships and impulsivity in action. The instability takes the form of leaving and entering relationships in a recurrent pattern as well as frequent changes in the nature of the relationship. The patient with borderline personality disorder often has an inordinate fear of being abandoned and exhibits extremes of thinking. For example, the relationship with the health care provider may involve the patient holding the provider in highest regard and later accusing them of incompetency. These patients exhibit impulsive, self-destructive behavior such as substance abuse, unsafe sex, binge eating, and reckless driving, and they engage in repeated threats and gestures of self-harm, including suicide. There is also marked emotional instability and intense, inappropriate anger. The borderline personality can also manifest as paranoid thoughts or dissociative symptoms. A borderline personality disorder can present an extremely difficult case management challenge to the unwary practitioner.

Histrionic personality disorder is characterized as pronounced emotional expression and attention seeking. Patients with this disorder can be provocative and sexually seductive and easily suggestible, and they may perceive relationships as more intimate than they really are. In other words, they think and act in ways that are inconsistent with boundaries normally maintained by orofacial pain patients. Patients with *narcissistic personality disorder* act in a grandiose manner and have an intense need for the admiration of others while displaying little empathy. These individuals expect the cli-

nician to respond to their needs at all hours, including during the weekend.

Cluster C

Cluster C personality disorders involve patients who are overly anxious or afraid as a predominant feature of their everyday experience. *Avoidant personality disorder* is associated with feeling socially inhibited and inadequate and being overly sensitive to any criticism. Patients with *dependent personality disorder* have a pervasive need to be taken care of, so there is excessive clinging and fear of being abandoned. These individuals will continue to seek care for their orofacial pain condition despite lack of improvement over time or even harm done. With *obsessive-compulsive personality disorder*, the patient's day-to-day life is ruled by a drive for perfection, orderliness, and being in control. There is limited openness to new ideas, and rules, details, and lists are very important. Individuals with obsessive-compulsive personality disorder do not like to work with others, keep everything they have owned (even worthless items), and hoard their resources in case something should happen in the future.

This last cluster of personality disorders can present a very real challenge to effective orofacial pain management. Patients can be so intensely focused on personal criticism, symptom improvement, or support from providers that anxiety and nervousness interfere with obtaining positive treatment outcomes. Body dysmorphic disorder has been reclassified into the category of obsessive-compulsive personality disorder, which is particularly relevant to the orofacial pain clinician because it causes the individual to experience extreme anxiety over a real or imagined physical flaw. For example, this diagnostic category could be applied to a patient who is convinced that there is a slight angle of a canine tooth that is responsible for his or her pain condition.

Consultation and Referral Strategies

Chronic orofacial pain management requires the availability of a multidisciplinary team that includes competent mental health care providers. Development of professional relationships with such providers should be a high priority for clinicians practicing in this field because it facilitates the implementation of informed referrals when necessary. Patients may present with red or yellow flags prompting more extensive evaluation or could need skills training or psychotherapy related to cognitive, behavioral, or emotional issues.

One effective approach for making a referral focuses on the patient's need for assistance with stress management. This strategy helps alleviate a patient's concerns about "being crazy" or being labeled as having a psychiatric disorder. The clinician should reassure the patient with statements such as the following to assuage any concerns:

- The referral is intended to address better ways of managing the consequences of pain.
- All pain is real.
- The relationship with the referring provider will continue through and beyond any referral therapy.
- The patient's physical status will continue to be monitored to detect any change that would warrant a different direction in treatment.
- The referral is not in any way a suggestion that the patient is "crazy."

Another effective strategy is to focus on getting help for physical self-regulation skills training. Patients will often be much more willing to visit with a mental health care provider when the referral focuses on learning how to better manage stress or learning new skills for controlling physical functioning. Bio-

feedback and its grounded focus on physical self-regulation is a topic dentists often discuss with their patients when arranging referrals.

Comprehensive Axis II Evaluation

The assessment of Axis II status must be a standard and routine part of the clinician's initial evaluation of the patient, even if only a brief assessment is used. Self-report screening instruments can be administered through a mailed packet or forms filled out while the patient is in the reception area; however, the interview portion is best deferred until the clinician has obtained enough pain and health history to form a matrix within which biobehavioral aspects can be anchored and appropriately interpreted. This part of the evaluation includes the range of biobehavioral factors and their interconnection with the standard pain history and typical review of systems, past medical history, and any family or social history. In addition, the clinician needs time to build rapport and trust with the patient before asking questions about personal functioning, and such questions need to fit into the overall sequence of information gathering. For example, everyone experiences stress (ie, the sense of being threatened or overwhelmed by events or the common daily hassles), so it is not enough to simply identify that a patient experiences stress, or even how often and to what extent. The stress experience has to be anchored into the pain and health histories for temporal and causal relationships to be identified, and thus the pain and health histories need to be first explored and understood. This part of an interview is often referred to as the *causal reasoning* portion.⁷⁶ The goal is to bring different parts together into a coherent network.

When a patient is referred to a mental health care provider for evaluation, the clinician can expect that the mental health care provider will perform a complete assessment and provide appropriate feedback in a timely manner. Typically, the evaluation can be performed within a

50- to 75-minute period and will include a review of the presenting complaints and history of onset from the perspective of the mental health care provider. The mental health care provider will also likely assess conditions that intensify or reduce the pain complaints as well as typical antecedents and consequences. It is not uncommon for the clinician to explore a typical day in the life of the patient. Pain cognitions, operant and respondent behavioral factors, activity management, and methods of coping are common features of a pain psychology evaluation. This may be followed by a careful review of the physical history including medication use; sleep issues; tobacco, caffeine, and alcohol use; and physical activity level. Mental status, mood, and ongoing emotional state are then assessed along with risks for harm to self and harm to others. This is typically followed by a review of any psychiatric history or hospitalizations. Then the current social support system, marital history, work history, and exposure to significant stressors or trauma are reviewed, as well as other relevant issues related to the patient's presentation (eg, spiritual or religious issues, compensation issues, legal issues). The data should be summarized in a readable report with appropriate recommendations for the clinician.

Biobehavioral Care: Integrated Care as the Standard of Care

While acute pain patients may respond to treatment in a linear and perhaps even dose-dependent manner, chronic pain patients typically do not. But even an acute pain patient with an obvious etiology and disorder may not respond to treatment in a linear manner if preinjury risk factors (eg, significant oral parafunctional behaviors, fear of reinjury) are present; in fact, the simple injury may result in further activation of those preinjury factors. Unless the initial evaluation sufficiently encompasses both the physical and the biobehavioral

domains, the clinician will not know or suspect if there are other factors that might interfere with treatment response. Furthermore, that level of assessment must be maintained at each follow-up as indicated based on patient response to treatment; otherwise, the poor treatment response can be accompanied by more physical treatments, medications, surgical referrals, and so forth.

If the patient's response to treatment cannot be expected to unfold in a linear manner, then the clinician must link the outcomes assessment goals for the primary physical domain with biobehavioral processes. This means that biobehavioral assessment is ongoing—at every follow-up visit, if necessary—just as physical assessment is. When properly done, this ongoing dual-axis assessment allows both the patient and the clinician to see whether the patient is responding appropriately to current treatment; if not, the direction for additional treatments or consultations should be evident to both the patient and the clinician.

In conclusion, the biobehavioral aspect of care must be viewed as central to patient care, not an optional add-on. For example, if physical exercise is part of the treatment but the patient's mobility is not improving, then the clinician should query this outcome. Considerations include inadequate assessment of the physical condition and incorrect execution of the exercises. Other possible causes should also be considered, such as depression, poor time management, avoidance behavior, personality disorder, and a passive coping style, among others. Without an adequate initial biobehavioral assessment, these possible causes of poor treatment outcome cannot be adequately interpreted and managed.

Biobehavioral models used in pain medicine across all disorders emphasize the partnership between provider and patient and the critical role that patient behavior plays in managing pain. TMD management can be likened to the management of hypertension in that it is enhanced through the simultaneous implementa-

tion of multiple treatments. For hypertension, these treatments include stress reduction, exercise, weight control, sodium restriction, relaxation training and biofeedback, and medications. Similarly, for a myofascial pain disorder, multiple self-administered treatments are effective: short-term analgesics, jaw use reduction, and thermal agents as well as longer-term stretching, parafunction control, relaxation training and biofeedback, and stress reduction. Each of these management strategies, from medication to stress reduction, is ultimately about behavioral self-regulation. For a patient to develop mastery in behavioral self-regulation, a biobehavioral model is needed to integrate all aspects of evaluation and treatment into an understandable framework.

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Glossary

Ant, antonym
Syn, synonym

A

abducens nerve motor cranial nerve (CN VI) supplying the lateral rectus muscle of the eye

abduction turning outward or laterally. *Ant:* Adduction.

ablation removal or detachment of a body part, usually by surgery

abrasion, tooth wearing away of the tooth structure by tooth-to-tooth contact; in contrast with chemical erosion or attrition

abscess localized collection of pus within preformed cavities formed by tissue disintegration

acceleration-deceleration injury. *See* Flexion-extension injury.

accommodation adjustment of the focus of the eye for various distances; also the rise in threshold of a nerve during constant, direct stimulation

acoustic meatus external cartilaginous and internal bony auditory canal that leads to the tympanic membrane. *Syn:* External auditory meatus.

acoustic myography electronic recording of muscle sounds, reflecting the mechanical component of muscle contraction

acoustic nerve sensory cranial nerve (CN VIII) with cochlear (hearing) and vestibular (equilibrium) fibers

acoustic neuroma benign tumor within the auditory canal arising from the acoustic nerve (CN VIII); frequently causes headache, hearing loss, tinnitus, facial pain, or numbness

acquired disorder postnatal aberration, change, or disturbance of normal development or condition that is not congenital but incurred after birth

acromegaly chronic metabolic condition caused by overproduction of growth hormone in the anterior pituitary gland and characterized by a gradual and marked elongation and enlargement of bones and soft tissues of the distal portion of the face, maxilla and mandible, and extremities

activation, muscle energy release in muscle tissue resulting in muscle contraction

activation, nerve depolarization of a neuron

active resistive stretch motion voluntarily forced against resistance of muscle, tendons, capsule, or intra-articular structures

active trigger point. *See* Myofascial trigger point: active.

G

acupuncture traditional Chinese practice of inserting needles into specific points along the meridians of the body to induce anesthesia, to alleviate pain, or for therapeutic purposes; experimental evidence shows that acupuncture produces an analgesic effect by triggering the release of enkephalin, a naturally occurring endorphin that has opiate-like effects. *See* Endorphin, Enkephalin.

acute malocclusion sudden alteration in the occlusal condition secondary to a disorder that is either perceived by the patient or clinically apparent

acute onset development that is sudden and recent. *Ant:* Insidious onset.

acute pain unpleasant sensation with a duration limited to the normal healing time or the time necessary for neutralization of the initiating or causal factors

adamantinoma. *See* Ameloblastoma.

adaptation the progressive adjustive changes in sensitivity that regularly accompany continuous sensory stimulation or lack of stimulation; the process by which an organism responds to stress in its environment

adaptive capacity relative ability to adjust to any type of change. *Syn:* Adaptive potential, Adaptive response.

adaptive potential. *See* Adaptive capacity.

adaptive response. *See* Adaptive capacity.

addiction, substance a state characterized by an overwhelming compulsion to continue use of a substance and to obtain it by any means, with a tendency to increase the dosage; a psychologic and usually a physical dependence on its effects; a detrimental effect on the individual and society; compare with dependence

adduction turning inward or medially. *Ant:* Abduction.

Aδ pain fibers thinly myelinated pain-conducting nerve fibers 1 to 4 μm in diameter

adenocarcinoma malignant adenoma

adenopathy any disease of the glands, especially of the lymphatic system, usually characterized by enlargement

adherence binding, clinging, or sticking together of opposing surfaces

adhesion molecular attraction between adjacent surfaces in contact; the abnormal fibrous joining of adjacent structures following an inflammatory process or as the result of injury repair

capsular a. fibrosis of the capsular tissues of a joint

fibrous a. *See* Adhesion: intracapsular.

intracapsular a. fibrosis between intra-articular surfaces within a joint capsule, resulting in reduced mobility of the joint. *Syn:* Fibrous ankylosis.

adjunctive therapy a supplemental procedure beyond the primary course of therapy

affect in psychology, the emotional reactions or feelings associated with an experience or mental state

afferent neural pathway nerve impulses transmitted from the periphery toward the central nervous system

agenesis defective development or absence of a body part

ageusia absence or impairment of the sense of taste

agonist muscle principally responsible for a particular movement; in pharmacology, a drug that acts at receptors on cells that are normally activated by a natural substance. *Ant:* Antagonist.

-al [suffix] pertaining to

-algia [suffix] pain

alogenic causing pain

algometer instrument for measuring the degree of sensitivity to painful stimuli

pressure a. instrument for reliably recording the pain pressure reaction point or pain pressure threshold

allo- [prefix] other

allodynia pain due to a stimulus that does not normally provoke pain

allostasis adaptation of neural, neuroendocrine, and immune mechanisms in the face of stressors

alveolar pertaining to the alveolar process of the mandible, including the tooth sockets, supporting bone, and associated connective tissues

ameloblastoma benign tumor of odontogenic epithelial origin. *Syn:* Adamantinoma.

analgesia absence of pain in response to stimulation that would normally be painful

analgesic agent that removes pain without loss of consciousness; relieving pain or insensitive to pain

anamnestic pertaining to medical and psychosocial history and past or current symptom state as recalled by the patient

Anamnestic Dysfunction Index epidemiologic symptom severity scale based on the history of disease or injury (Helkimo index)

anastomosis a connection between two separate structures

anesthesia absence of all feeling or sensation, especially pain

a. dolorosa pain in an area or region that is anesthetic

block a. regional anesthesia resulting from an anesthetic injected into or near a nerve trunk

central a. anesthesia due to central blocking of nerve impulses or a disease of the nerve centers

general a. drug-induced unconscious state typically used for surgical procedures

local a. anesthesia due to local blocking of nerve impulses in a limited part of the body

regional a. analgesia of a body part due to proximal blocking of nerve impulses by local anesthetic

aneurysm a sac filled with fluid or clotted blood formed by widening of the wall of an artery, a vein, or the heart

saccular a. an unusual, localized widened area affecting only part of the circumference of the arterial wall

angular cheilitis inflammation of the corners of the mouth usually due to candidiasis

ankylosing spondylitis ossification of the spinal ligament resulting in a bony encasement of the joint; more common in boys; onset most often between 9 and 12 years of age. *Syn:* Spondylosis.

ankylosis stiffening or immobilization of a joint as the result of disease, trauma, or congenital process with bony union across the joint; also, fibrosis without bony union; compare with adhesion

bony a. osseous union of adjacent, usually movable, body parts. *Syn:* Synostosis, True ankylosis.

dental a. fusion of the tooth to the surrounding bony alveolus due to ossification of the periodontal membrane

extracapsular a. rigidity of the periarticular tissues resulting in joint stiffness or immobilization. *Syn:* False ankylosis.

fibrous a. *See* Adhesion: intracapsular.

osseous a. characterized by radiographic evidence of bone proliferation with marked deflection to the affected side and marked limited laterotrusion to the contralateral side

anorexia diminished appetite or aversion to food

a. nervosa psychiatric disorder characterized by distortions in body image and aversion to food, resulting in extreme weight loss and amenorrhea in women; usually occurring in young women

ANS. *See* Autonomic nervous system.

ansa hypoglossi also known as the ansa cervicalis; a nerve loop supplying the infrahyoid muscles formed by descending fibers of the hypoglossal nerve, the superior nerve root to C1 and C2, and inferior root to C2 and C3

antagonist muscle whose function is opposite the agonist or prime mover; in pharmacology, a drug that diminishes the effect of another drug or naturally occurring substance through stimulation at the same receptor sites. *Ant:* Agonist.

anterior bite plate a hard acrylic resin appliance that provides for occlusal contact only between the anterior teeth

anterior repositioning appliance, mandibular intraoral device that guides or positions the mandible to a position forward of maximal intercuspation

anticholinergic an agent that blocks the action of acetylcholine in the central and peripheral parasympathetic nerves; the action of that agent

anticonvulsant an agent used to control or prevent convulsions; the action of that agent

antidepressant an agent used to treat depression; the action of that agent

antidromic conducting impulses in the direction opposite normal

antidromic release secretion of chemicals and neurotransmitters at the receptor that occurs with antidromic nerve activity

antinuclear antibody (ANA) antibody directed against nuclear antigens, found primarily in the serum of patients with systemic lupus erythematosus but also in patients with rheumatoid arthritis, scleroderma, and other connective tissue disorders

antipyretic an agent that brings about fever reduction; the action of that agent

anxiety feeling of apprehension, uncertainty, or dread of a future threat or danger, accompanied by tension or uneasiness

anxiety disorder a category of mental illness that includes obsessive-compulsive disorder, posttraumatic stress disorder, phobia, and panic disorder, the symptoms of which are not relieved by reassurance, with resulting limitations in adaptive functioning

aphasia inability to speak or comprehend written or spoken language; caused by brain injury or lesions or of psychogenic origin

aplasia incomplete or arrested development of a structure due to failure of normal development of the embryonic primordium

apnea temporary cessation of breathing

aponeurosis flat, fibrous tendon sheath that invests and attaches muscle to bone or other tissue

appliance device or prosthesis used to provide or facilitate a particular function or therapy

Arnold-Chiari malformation a structural malformation of the brainstem and dura caused by herniation of the cerebellar tonsils 3 to 5 mm below the foramen magnum or caudally to C2

arteriovenous malformation altered morphology, weakening, or distension of an artery or vein; arteritis; inflammation of an artery

arteritis cranial manifestation of giant cell arteritis characterized by fever, anorexia,

weight loss, leukocytosis, tenderness over the scalp and along facial and temporal arteries, headache, and jaw claudication; may lead to blindness; uncommon before the age of 60 years; associated with significantly elevated erythrocyte sedimentation rate. *Syn:* Cranial arteritis, Giant cell arteritis, Temporal arteritis.

arthralgia pain of joint origin affected by jaw movement, function, or parafunction and replication of this pain with provocation testing

arthritis [*pl:* **arthritides**] pain of joint origin with clinical characteristics of inflammation or infection: edema, erythema, and/or increased temperature

arthrocentesis puncture of a joint with a needle or a catheter, followed by removal of fluid

arthrodial pertaining to gliding movement by two adjacent surfaces

arthrodial joint joint that allows gliding movement of the parts

arthrogenous pain pain originating from joint structures

arthrogram radiograph of a joint

arthrography visualization of a joint by radiopaque contrast and radiography

arthrogryposis fixation of a joint in a flexed or contracted position that may be related to innervation, muscles, or connective tissue

arthrokinematics, TMJ the description of the movement between joint surfaces

arthrokinetics, TMJ temporomandibular joint motion. *Syn:* Arthrokinematics, TMJ.

arthropathy any disease or disorder that affects a joint

arthroplasty surgical repair or plastic reconstruction of a joint

arthroscopy direct visualization of a joint with an endoscope

arthrosis disease of a joint evidenced by bony alterations of a joint or articulation

arthrotomography tomographic radiography of a joint

arthrotomy surgical incision of a joint

articular pertaining to a joint

a. disc. *See* intra-articular.

a. remodeling. *See* Remodeling.

- a. capsule** fibrous connective tissue sac that encloses a synovial joint and limits its motion
- articulate** in dentistry, the state of the teeth being brought together into occlusion
- articulation, TMJ.** *See* Temporomandibular joint.
- articulator** mechanical device for attachment of dental casts that allows movement of the casts into various eccentric relationships to represent jaw movement
- asthenia** weakness or lack of energy
- asymmetry** lack of symmetry due to inequality in size, shape, movement, or function between two corresponding parts on opposite sides of the body
- ataxia** impaired ability to coordinate movement or neuromuscular dysfunction
- atrophy** progressive decline in size or wasting away of tissue, organ, or body part, often due to denervation, disease, aging, lack of use, or malnutrition. *Ant:* Hypertrophy.
- attrition** wearing away by friction or rubbing; a wearing away of tooth structures due to bruxism
- atypical facial pain.** *See* Persistent idiopathic facial pain.
- atypical odontalgia.** *See* Persistent idiopathic facial pain.
- atypical tooth pain.** *See* Persistent idiopathic facial pain.
- aura** a subjective sensation (as of voices, colored lights, or crawling and numbness) experienced at the onset of a neurologic condition and especially a migraine or epileptic seizure
- auricle** visible portion of the external ear. *Syn:* Pinna.
- auriculotemporal nerve** sensory branch of the mandibular division of the trigeminal nerve; innervates the external acoustic meatus, the tympanic membrane, the lateral aspect of the TMJ capsule, the parotid sheath, the skin of the auricle, and the temple
- auriculotemporal neuralgia.** *See* Neuralgia: auriculotemporal.
- auscultation** the diagnostic technique of listening for sounds within the body
- autogenous graft** graft using one part of a patient's body for another
- autoimmune disorder** disease in which the body produces a disordered immunologic response against itself, causing tissue injury; eg, rheumatoid arthritis, scleroderma
- autologous** occurring naturally or normally within a structure or tissue
- autonomic effects of central excitation** secondary stimulation of internuncial neurons during pain, leading to transmission of efferent autonomic impulses that produce effects that differ from those normally associated with the physiology of pain
- autonomic nervous system (ANS)** a division of the peripheral nervous system distributed to smooth muscle and glands throughout the body, comprising the sympathetic and parasympathetic nervous systems, involved in motor (efferent) transmission, functioning independently of conscious control
- avascular** lacking in blood vessels
- avascular necrosis (AVN)** bone infarction not associated with asepsis but with circulatory impairment (vascular occlusion), leading to bone necrosis and collapse of joint surface into underlying infarction
- axon** long myelinated or unmyelinated portion of a nerve cell that transmits information from the nerve cell body

B

- behavior** actions or reactions under specific circumstances
- behavior modification** psychotherapy that attempts to modify observable patterns of behavior by the substitution of a new response to a given stimulus
- Bell's palsy** peripheral facial paralysis due to lesion of the facial nerve (CN VII)
- benign** mild, nonprogressive, nonrecurrent, and nonmalignant character of a tumor
- benign masseteric hypertrophy** nonmalignant increase in size or bulk of masseter muscles of unknown etiology, usually bilateral
- benign migratory glossitis.** *See* Geographic tongue.

biobehavioral behavioral factors as they contribute to the functioning of biologic systems

biofeedback training therapy that teaches the voluntary modification of physiologic activity or autonomic function using equipment that gives a visual or auditory representation of the activity or function

biomechanical pertaining to the application of mechanical laws, such as those relating to intrinsic or extrinsic force, to living structures, in particular, the locomotor system

biopsychosocial the complex interactions between biology, psychologic states, and social conditions that bring about and/or maintain function and dysfunction

bite guard misnomer. *See* Stabilization appliance.

blepharospasm tonic spasm of the orbicularis oculi producing more or less complete closure of the eyelid

body dysmorphic disorder (BDD) preoccupation with a defect in appearance that is imagined; markedly excessive concern over a slight physical anomaly

border movements movements of the mandible at the boundary or margin of the envelope of movement as determined by the joint anatomy, joint capsule, ligaments, and associated muscles

brachycardia. *See* Bradycardia.

brachycephalic head form that is rounded and short in the anteroposterior direction and broad in width

bracing. *See* Bruxism.

bradycardia abnormally slow pulse rate (< 60 beats/min)

bradykinesia abnormally slow movement

bradykinin plasma kinin that is a potent vasodilator and incites pain

brainstem neural tissue that connects cerebral hemispheres with the spinal cord, comprising the medulla oblongata, pons, and midbrain

breathing-related sleep disorder disorder characterized by interruptions of sleep due to breathing-related medical conditions such as obstructive or central sleep apnea or central alveolar hypoventilation syndrome

Briquet syndrome. *See* Somatic symptom disorder.

bruxism a repetitive jaw-muscle activity characterized by clenching or grinding of the teeth and/or by bracing or thrusting of the mandible; can occur during sleep (sleep bruxism) or during wakefulness (awake bruxism)

burning mouth syndrome (BMS) dysesthesia described as a burning sensation in the oral cavity occurring in the absence of clinically apparent mucosal abnormalities or laboratory findings and often perceived as painful

bursa saclike cavity found in connective tissue at places where friction would otherwise develop; lined with synovial membrane and filled with viscous synovial fluid. *See* Synovial joint.

bursitis inflammation of a bursa

C

calcified cartilage zone calcified tissue between the articular soft tissue and the subchondral bone in synovial joints

calcium pyrophosphate dehydrate crystals mineral deposits in synovial fluid of joints with chondrocalcinosis

canine rise. *See* Canine-protected occlusion.

canine-protected occlusion occlusion where the canine acts as the sole discluder in laterotrusion. *Syn:* Canine-protected articulation.

capsular pertaining to the joint capsule

capsular fibrosis. *See* Adhesion: capsular.

capsular ligament, TMJ a ligament that separately encapsulates the upper and lower TMJ synovial membrane

capsule, joint. *See* Articular capsule.

capsulitis inflammation of a capsule, its associated capsular ligaments, or the disc attachments in response to mechanical irritation or systemic disease

adhesive c. adhesion and restriction of joint motion due to reduced joint space volume and swollen synovial membranes during a joint capsulitis condition

carotid artery principal artery of the neck supplying the neck, face, skull, brain, middle ear, pituitary gland, orbit, and choroid

- plexus of the lateral ventricle; the paired common carotid divides at the upper border of the thyroid cartilage into the external and internal carotid arteries
- carotidynia** pain due to inflammation of the carotid artery, usually self-limiting
- cartilage** dense fibrous connective tissue covering most articular surfaces and some parts of the skeleton
- articular c.** a thin layer of cartilage located on the joint surfaces of some bones
- fibrous c.** the articulating surface cartilage found in the TMJ, which has a greater ability to repair itself and is more resistant to stress, also called fibrocartilage
- hyaline c.** the articulating surface cartilage found in most synovial joints
- cast, dental** a model or representation of the teeth and supporting bone, usually made of stone or plaster. *Syn:* Diagnostic cast, Study cast, Study model.
- catecholamines** biogenic amines with a sympathomimetic action
- caudal** inferior, toward the tail. *Syn:* Inferior; *Ant:* Cephalad.
- causalgia.** See Complex regional pain syndrome II (CRPS II).
- cellulitis** a diffuse inflammatory process that spreads along fascial planes and through cellular tissue spaces, especially the subcutaneous tissues
- acute c.** cellulitis accompanied by swelling, supuration, and pain
- chronic c.** cellulitis with little swelling or pain
- central excitation effects.** See Autonomic effects of central excitation.
- central nervous system (CNS)** the brain and spinal cord
- central pain** pain initiated or caused by a primary lesion or dysfunction in the central nervous system¹; also, pain resulting from damage to the central nervous system; eg, thalamic syndrome and spinal cord injury pain
- centric occlusion (CO)** the occlusion of opposing teeth when the mandible is in centric relation; this may or may not coincide with the maximal intercuspal position²
- centric relation (CR)** a maxillomandibular relationship, independent of tooth contact, in which the condyles articulate in the anterior-superior position against the posterior slopes of the articular eminences²
- cephalad** superior, toward the head. *Syn:* Cranial rostral, superior; *Ant:* Caudal.
- cephalalgia** pain or ache in the head. *Syn:* Headache.
- cephalic** pertaining to the head or structure of the head
- cephalogram** radiograph of the head
- cerebral ischemia** deficiency in blood supply to part of the brain due to constriction or actual obstruction of blood vessel
- cerebral palsy** motor function disorder caused by a permanent, nonprogressive brain defect or lesion present at birth or shortly thereafter; deep tendon reflexes are exaggerated, fingers are often spastic, and speech may be slurred
- cervical** pertaining to the neck
- cervical plexus** network of nerves formed by the ventral branches of the upper four cervical nerves
- cervical spine disorder (CSD)** a category of disorders involving the muscles, facet joints, discs, and nerves of the cervical spine
- cervicalgia** pain of the structures of the neck, including referred pain from noncervical origin
- cervicogenic** originating in the structures of the neck
- cervicogenic headache** headache characterized by a moderately severe, dull, dragging, unilateral headache without side-shift, provoked or aggravated by neck movements and accompanied by any of the following symptoms: lacrimation, conjunctival hyperemia, dizziness, nausea, vomiting, and sensitivity to light and noise
- chief complaint (CC)** the patient's statement of the main problem or primary concern
- chondritis** inflammation of cartilage
- chondroblastoma** benign tumor, derived from precursors of cartilage cells, sometimes showing scattered areas of calcification and necrosis

chondrocalcinosis a recurrent arthritic disease in which calcified deposits of calcium hypophosphate crystals collect in synovial fluid, articular cartilage, and adjacent soft tissues, leading to gout-like attacks of pain and swelling of the involved joints. *Syn:* Pseudogout, Pyrophosphate arthropathy.

chondroma benign cartilaginous tumor

chondromalacia softening of cartilage, sometimes accompanied by swelling, pain, and degeneration

chondron cell cluster in the cartilaginous zone of the articular cartilage

chondrosarcoma malignant tumor of cartilaginous cells or their precursors that may contain nodules of calcified hyaline cartilage

chorea a convulsive nervous disease with involuntary and irregular jerking movements

chronic overlapping pain conditions (COPCs) common coexisting pain conditions; eg, TMD, fibromyalgia, headache, irritable bowel syndrome

chronic pain pain that persists when other aspects of disorder or disease have resolved and typically lasts more than 6 months or beyond the normal time for healing of an acute injury or pain; may have associated unpleasant sensory, perceptual, and emotional experiences accompanied by behavioral and psychosocial responses

claudication muscle ischemia due to decreased arterial blood flow to an area causing intermittent pain

clenching. *See* Bruxism.

clicking joint noise, TMJ distinct snapping or popping sound emanating from the TMJ during joint movement or with joint compression

reciprocal c.j.n., TMJ a pair of clicks, one of which usually occurs during opening at a different location than the second one, which occurs during closing movements of the jaw; associated with disc displacement with reduction

clock-regulated treatment at regular intervals; eg, every 6 hours

closed lock. *See* Disc displacement: without reduction with limited opening.

cluster headache severe unilateral head and facial pain, often accompanied by involun-

tary lacrimation, with localized extracranial vasodilatation in the periorbital region contributing to the pain and conjunctival congestion; occurs in bouts or clusters, sometimes with clockwork regularity, usually occurring during the night and lasting 30 to 120 minutes. *Syn:* Histaminic cephalalgia, Horton headache, Horton syndrome.

CNS. *See* Central nervous system.

cocontraction reflexive contraction of antagonist muscles resulting from noxious stimuli of a sensory field of a joint, soft tissue, or other structure to prevent movement or provide stabilization of the painful area tissues. *Syn:* Protective muscle splinting.

cognition the mental process of knowing, thinking, learning, and judging

cognitive behavioral therapy (CBT) therapy focused on changing attitudes, assumptions, perceptions, and patterns of thinking

collagen disease. *See* Connective tissue: disorders.

collateral ligaments, TMJ paired supportive ligaments on the lateral and medial aspects of the TMJ capsule, attaching the articular disc to the mandibular condyle; the ligaments allow rotational disc movement in an anterior-posterior axis only

complex regional pain syndrome I (CRPS I) pain syndrome with onset often after traumatic event; symptoms are not limited to the distribution of a peripheral nerve and are disproportional to the injury; edema, decreased cutaneous blood flow, atrophy of the skin, hair, and nails, autonomic changes in the region of the pain, hyperalgesia, or allodynia may occur at some time in the course of development; formerly reflex sympathetic dystrophy (RSD)

complex regional pain syndrome II (CRPS II) a syndrome of persistent severe burning sensation, allodynia, and hyperpathia, usually following partial injury of a peripheral nerve and combined with vasomotor and pseudomotor dysfunction; later, the condition is usually accompanied by trophic changes to the skin, hair, and nails; formerly causalgia¹

compression of joint pressing together of joint surfaces

- computer-assisted tomography** misnomer. See Tomography: computed.
- computerized axial tomography** misnomer. See Tomography: computed.
- computerized tomography (CT)** misnomer. See Tomography: computed.
- computerized transaxial tomography** misnomer. See Tomography: computed.
- conditioned pain modulation** a neuronal mechanism where pain inhibits pain at all levels in the CNS
- condylar agenesis** developmental abnormality characterized by the absence of a condyle
- condylar fracture** fracture of the head or neck of the mandibular condyle, further characterized as intracapsular or extracapsular, displaced or nondisplaced
- condyle** rounded, articular end of a bone
- condylectomy** surgical removal of the entire condyle
- condylolysis.** See Condylolysis.
- condylotomy** surgical division or reshaping of a condyle
- condylolysis** idiopathic resorption or dissolution of a condyle. *Syn:* Condylolysis.
- congenital disorder** developmental disorder present at or before birth
- conjunctiva** mucous membrane covering the anterior surface of the eyeball and lining the eyelids
- conjunctival injection** dilation of the vasculature of the conjunctiva
- connective tissue** tissue of mesodermal origin that supports and binds other tissues; includes elastic or collagenous fibrous connective tissue, bone, and cartilage; connective tissues are highly vascular with the exception of cartilage
- c.t. disorders** a group of connective tissue diseases of unknown etiology sharing common anatomical and clinical features. *Syn:* Collagen disease, Mixed connective tissue disease.
- continuous passive motion (CPM)** cyclic motion of a body part caused by another individual or machine that moves an articulation through a determined range of motion
- contraction** normal shortening, tightening, or reduction in size or length of a muscle fiber
- contracture** abnormal shortening
- capsular c., TMJ.** See Adhesion: capsular.
- muscular c.** sustained increased resistance to passive muscle stretch due to reduced muscle length
- myofibrotic c.** muscular contracture resulting from excessive fibrosis of the muscle, usually as a sequela of trauma or infection
- myostatic c.** muscular contracture resulting from reduced muscle stimulation
- contralateral** pertaining to the opposite side. *Ant:* Ipsilateral.
- contrast medium** radiopaque material injected before imaging that renders certain tissues or spaces opaque
- contributing factor** condition or action that contributes to the occurrence or aggravation of a disease or disorder
- contusion of joint** traumatic joint bruising characterized by acute synovitis, effusion, and possible hemarthrosis, but without fracture
- convergence, neural** the synapsing of a neuron with several others
- conversion disorder** mental disorder characterized by disturbances in sensory and motor function, due to unconscious needs and conflicts, in the absence of organic disease
- coping mechanisms** cognitive and behavioral efforts to manage specific tasks, problems, or situations
- cordotomy** an operation to divide bundles of nerve fibers within the spinal cord to relieve chronic pain; usually performed in cases where pain has not responded to more conservative treatments
- coronal** pertaining to the crown of the head or tooth or the coronal suture of the skull
- coronal plane.** See Frontal plane.
- coronoid hyperplasia** benign overgrowth of the coronoid process of the mandible that may result in limited jaw opening when its movement is obstructed by the zygomatic process
- coronoid process** conical process on the anterosuperior surface of the mandibular ramus that serves as the attachment of the temporalis muscle

coronoid process impingement restricted jaw movement due to coronoid hyperplasia

cortical bone dense, solid outer layer of a bone that surrounds the medullary cavity

corticosteroid a crystalline steroid found in the adrenal cortex

Costen syndrome syndrome of dizziness, tinnitus, earache, stuffiness of the ear, dry mouth, burning in the tongue and throat, sinus pain, and headaches that an otolaryngologist in 1934 attributed to overclosure of the bite and posterior displacement of the mandibular condyle

cracked tooth syndrome set of symptoms including sporadic, sharp, momentary pain on biting or releasing along with occasional pain from cold food or drink due to incomplete fracture of the tooth

cranial. *See* Cephalad.

cranial arteritis. *See* Arteritis.

cranial nerves (CNs) twelve pairs of nerves that have their origin in the brain

cranial neuralgia. *See* Neuralgia: cranial.

craniocervical relating to both the cranium and the neck

craniofacial relating to both the face and the cranium

craniomandibular. *See* Temporomandibular.

craniomandibular disorders (CMDs). *See* Temporomandibular disorders.

cranium the bones of the skull that encase the brain

crepitation rough, sandy, diffuse noise or vibration produced by the rubbing together of irregular bone or cartilage surfaces, usually identified with osteoarthritic changes when heard in joints. *Syn:* Crepitus, Grating.

crepitus. *See* Crepitation.

crossbite condition in which normal labiolingual or buccolingual relationship between the maxillary and mandibular teeth is reversed

cryoanalgesia application of extreme cold to an affected nerve to deliberately disrupt its ability to transmit pain signals

cryotherapy a peripheral ablative procedure in which the offending trigeminal branch is frozen under general or local anesthesia

CT. *See* Tomography: computed.

CT scan. *See* Tomography: computed.

cutaneous relating to the skin

cycle a succession of events or symptoms

D

deafferentation partial or total loss of afferent neural activity to a particular body region through removal of part of the neural pathway

deafferentation pain usually constant pain perceived in a localized area resulting from the loss or disruption of afferent neural pathways

debridement excision of devitalized tissue and foreign matter from a diseased area or wound

decompression of a joint removal or release of pressure on a joint

deep brain stimulation (DBS) a type of neurostimulation that uses electrical signals from an implanted generator to stimulate targeted nerves or structures in the brain to relieve neurologic symptoms such as motor dysfunction

deep-heat therapy diathermy and ultrasound

degeneration tissue deterioration with soft tissue, cartilage, and bone converted into or replaced by tissue of inferior quality; failure of articulation to adapt to loading forces, resulting in impaired function; degenerative arthritis. *See* Osteoarthritis.

degenerative joint disease (DJD). *See* Osteoarthritis.

deglutition the act of swallowing

delayed-onset muscle soreness muscle pain caused by interstitial inflammation after intermittent overuse

δ sleep a state of deep usually dreamless sleep that is characterized by δ waves and a low level of autonomic physiologic activity

demyelination loss of myelin from the sheath of a nerve

denervation resection or removal of nerve tissue

dentofacial orthopedics. *See* Orthodontics.

dentulous with teeth

dependence use of a chemical substance resulting in the development of a physiologic need to the extent that withdrawal symptoms occur when the substance is re-

- moved; to be distinguished from addiction, in which psychologic reliance also occurs
- depression, major** psychiatric disorder characterized by prolonged periods of depression and often with associated symptoms of poor appetite or overeating, insomnia, hypersomnia, low energy or fatigue, low self-esteem, poor concentration, and feelings of hopelessness
- depression of mandible** movement of the mandibular alveolar processes away from the maxilla; a component of normal jaw opening. *Ant:* Elevation of mandible, Mandibular closure.
- depression, psychologic** mood characterized by feelings of sadness, helplessness, hopelessness, guilt, despair, and futility. *Syn:* Dysthymia.
- deprogrammer** an appliance used to interfere with the proprioceptive mechanism during chewing or mandibular closure
- derangement** a disturbed arrangement of body parts
- dermatome** superficial zone of reference on the skin where pain is felt with stimulation of a single posterior spinal nerve root or cranial neural segment
- developmental disorder.** *Ant:* Acquired disorder. *See* Congenital disorder.
- deviation in form** irregularities or aberrations in the form of soft and hard intracapsular articular tissues
- deviation on mandibular opening** noticeable departure from the midline of the mandible of ≥ 2 mm to either the right or left during maximum unassisted opening, with or without correction
- diagnosis** distinguishing one disease from another or determining the nature of a disease from a study of the history, signs, symptoms, and physical examination results
- diagnostic cast.** *See* Cast, dental.
- diarthrodial joint** a freely moving joint enclosed in a fluid-filled synovial cavity and limited variously by muscles, ligaments, and bone
- diathermy** deep-heat therapy from high-frequency electric current
- differential diagnosis** differentiation of two or more diseases with similar symptoms to determine which is the correct diagnosis
- disability** alteration of the patient's capacity to meet personal, social, and/or occupational responsibilities as determined by behavioral, psychologic, and psychosocial assessments; disability is a social and not a medical term
- disc** circular, rounded, flat plate
- intra-articular d.** intra-articular, circular, rounded, platelike fibrocartilaginous structure in some synovial joints. *Syn:* Articular disc; *Misnomer:* Meniscus.
- disc derangement.** *See* Disc displacement.
- disc detachment** a peripheral separation of the disc from its capsular, ligamentous, or osseous attachments
- disc dislocation.** *See* Disc displacement.
- disc displacement** in the TMJ, an abnormal position of the intra-articular disc relative to the mandibular condyle and the temporal fossa. *Syn:* Disc derangement, Disc interference disorder.
- d.d. with reduction** a disc displacement at the intercuspal position, with reestablishment of a normal anatomical relationship between the disc and condyle during condylar rotation or translation. *Syn:* Reducing disc.
- d.d. with reduction with intermittent locking** an intracapsular biomechanical disorder in which the condition changes between a disc displacement with reduction and a disc displacement without reduction with limited opening
- d.d. without reduction with limited opening** in the closed mouth position, the disc is in an anterior position relative to the condylar head, and the disc does not reduce with opening of the mouth; the patient has a maximum assisted opening (passive stretch) of less than 40 mm
- d.d. without reduction without limited opening** in the closed mouth position, the disc is in an anterior position relative to the condylar head, and the disc does not reduce with opening of the mouth; the patient has a maximum assisted

opening (passive stretch) of 40 mm or greater

disc interference disorder. See Disc displacement.

disc perforation a circumscribed tear in the articular disc permitting communication between the superior and inferior joint spaces, with no disruption at the peripheral attachments to the capsule, ligaments, or bone

disc space radiolucent area in a TMJ radiograph between the mandibular condyle and the articular fossa

disc thinning degenerative decrease in the thickness of the articular disc

disc-condyle complex in the TMJ, the articulation of the condyle with the disc, which functions as a simple hinge joint

discectomy arthrotomy with complete removal of the intra-articular disc

discoplasty correction or improvement in the contour of an intra-articular disc

disc-repositioning surgery, TMJ arthrotomy with intent of reestablishing normal anatomical disc-condyle relationship

disk misnomer. See Disc.

dislocation of condyle. See Luxation, Subluxation.

disorder disturbance of function, structure, or mental state

displacement removal from the normal or usual position or place

distraction of the condyle separation or forced downward movement of the condyle from the articular fossa without injury or dislocation of the parts

diurnal pertaining to or occurring in the daylight hours. *Ant:* Nocturnal.

dizziness a disturbed sense of relationship to space and unsteadiness with a feeling of movement within the head; to be distinguished from vertigo

dolichocephalic head shape that is oval and long anteroposteriorly and narrow in width

Doppler effect the apparent change in the frequency of a wave resulting from relative motion of the source in relation to the receiver

Doppler ultrasonography the application of the Doppler effect to ultrasonic scanning,

with ultrasound echoes converted to (amplified) sound or graphic waves

dorsal column stimulator electric stimulation of nervous tissues to produce paresthesia in a specific portion of the spinal cord known as the dorsal column; also called spinal cord stimulation

drug pump a small device surgically placed under the skin to deliver microdoses of medication, usually to the intrathecal space (space surrounding the spinal cord containing fluid); because the drug is delivered directly to the spinal cord, a smaller dose is required, which helps minimize systemic side effects

dys- [prefix] bad, disordered, difficult

dysarthria defective articulation secondary to motor deficit involving the lips, tongue, palate, or pharynx

dysarthrosis deformity or malformation of a joint whereby there is impairment of joint motion

dysautonomia malfunctioning of the autonomic nervous system that hinders normal activities of daily living or causes total disability; dysautonomia can interfere with the ability of the cardiovascular system to compensate for changes in posture, especially when changing rapidly from a supine to standing posture, and dizziness or syncope results; systemic effects can also cause tachycardia or diabetes insipidus; dysautonomias can occur from trauma to the autonomic nervous system, viral infection, genetic disorders, chemical exposure, pregnancy, or autoimmune disorders

dyscrasia morbid condition referring to an imbalance of the component parts

dysesthesia an unpleasant abnormal sensation, whether spontaneous or evoked¹

dysfunction abnormal, impaired, or altered function

dysfunction index system of quantifying the severity of dysfunction

clinical d.i. a severity index developed by Helkimo and based on the symptoms and signs found during a clinical examination

dysgeusia distortion of the sense of taste

dyskinesia motor function disorder with impairment of voluntary movement, characterized by spontaneous, imprecise, involuntary, irregular movements with stereotypical patterns

tardive d. drug-induced dyskinesia

dysmasesis difficulty with mastication

dysostosis abnormal condition characterized by defective ossification, especially involving fetal cartilage

dysphagia difficulty in swallowing

dysphasia speech impairment due to centrally induced lack of coordination, including failure to arrange words in proper order

dysphonia impairment of the voice; speaking difficulties

dysphoria emotional distress, disquiet, restlessness, or malaise

dysplasia abnormality of development

dysthymia. *See* Depression, psychologic.

dystonia excessive, involuntary and sustained muscle contractions that may involve the face, lips, tongue, and/or jaw

focal d. localized dystonia characterized by momentary sustained contracture of involved muscles

dystrophy developmental change in muscles resulting from defective nutrition, characterized by fatty degeneration and increased size but decreased strength, and not involving the central nervous system

E

eccentric jaw relation mandibular posture that is peripheral or away from a centered jaw position or intercuspal position

edema abnormal accumulation of fluid in cells, tissue spaces, or cavities

edentulous without teeth

efferent neural pathway neural impulse transmitted away from the central nervous system

efficacy ability of a drug or treatment to produce a result

effusion escape of fluid from blood vessels or lymphatics into a body cavity or tissue

Ehlers-Danlos syndrome autosomal-dominant inherited disorder of connective tissues

characterized by lax joints, skin elasticity, fragility, and pseudotumors

elastic tissue connective tissue with approximately 30% elastin, a yellow fibrous mucoprotein

electrodiagnostic testing use of electrical devices to assist in diagnosis

electrogalvanic stimulation (EGS) electrotherapy using direct current (galvanism) to produce muscle fiber contraction; also used in iontophoresis and as a pain-relieving modality

electromyography (EMG) graphic recording of the intrinsic change in the electric potentials of muscles

needle e. graphic recording of electrical activity in muscle obtained by insertion of a needle electrode

surface e. graphic recording of electrical activity in muscle obtained by placement of an electrode on the skin overlying the muscle

electrotherapy treating disease by use of electrical direct current (galvanism) or alternating current (faradism)

elevator masticatory muscles paired masseter, medial pterygoid, and temporalis muscles, the main action of which is to elevate the mandible

eminence prominence or projection of a bone. *Syn:* Tubercle.

emission scintigraphy imaging process to show areas of relatively rapid bone turnover by administration of radiolabeled material

emotional motor system theory contending that thoughts and emotions create neuroendocrine-mediated motor responses

enarthrosis joint joint with a ball and socket arrangement. *Syn:* Spheroidal joint.

end-feel quality of resistance felt during joint manipulation from full active stretch to full passive stretch

endocrine secreting a hormone from a gland directly into the circulatory or lymphatic system

endogenous produced or originating from within a tissue or organism

endorphin endogenous antinociceptive opioid substance in the cerebral spinal fluid that is synthesized in the nerve cells and

acts as an inhibiting neurotransmitter on nociceptive pathways. *Syn:* Enkephalin.

endoscope instrument for examining the interior of a body cavity

enkephalin. *See* Endorphin.

enophthalmos posteriorly positioned eyeballs within the orbit

envelope of motion the three-dimensional space circumscribed by border mandibular movements and by the incisal and occlusal contacts of a given point of the mandible

ephapsis electric cross-talk between nerve fibers

epidemiology science concerned with defining and explaining the interrelationships of factors that determine disease frequency and distribution

epigenetics an emerging area of research that focuses on the impact of environmental factors on the global expression of genes

epilepsy group of neurologic disorders characterized by recurrent seizures, at times accompanied by sensory disturbance, abnormal behavior, alterations in level of consciousness, and electroencephalographic changes

equilibration, occlusal. *See* Occlusal equilibration.

Erb palsy a condition that is mainly due to birth trauma; it can affect one or all five primary cervical nerves that supply the movement and feeling to an arm; the paralysis can be partial or complete; the damage to each nerve can range from bruising to tearing; also called brachial plexus paralysis

erosion of teeth wearing away of the nonoccluding surfaces of the dentition, especially by chemical means

erythema migrans. *See* Geographic tongue.

erythema multiforme an acute skin and mucous membrane disease characterized by papules, tubercles, and macules lasting for several days, with burning, itching, and sometimes headache symptoms

erythrocyte sedimentation rate (ESR) rate at which red blood cells settle in a tube of unclotted blood, expressed in millimeters per hour; elevated ESR indicates the pres-

ence of inflammation but is not specific for any disorder

etiology cause of a specific disorder

euryprosopic having a facial form that is short, broad, and flat

Eustachian tube opening from the middle ear cavity into the pharynx

Ewing sarcoma endothelial myeloma, a malignant bone tumor that develops from bone marrow; most frequently in long bones, with pain, fever, and leukocytosis

exacerbating factor factor that increases the seriousness of a disease or disorder as marked by greater intensity or frequency in the signs or symptoms

excursion of mandible movement of the mandible away from the median or intercuspal occlusion position

exophthalmos protrusion of eyeballs

extension unbending movement of a joint.
Ant: Flexion.

external away from the center of the body or outside a structure

external auditory meatus. *See* Acoustic meatus.

extracapsular outside or external to the capsule, usually of a joint. *Ant:* Intracapsular.

extracranial outside or external to the cranium

extrinsic originating outside of a part where it is found or on which it acts

extrinsic trauma trauma originating from outside an organ system or individual

extrusion expulsion by force, thrusting, or pushing out

F

facet small, smooth planar area on a hard surface

f. joint. *See* Zygapophyseal.

facial pertaining to the face or anterior part of the head from forehead to chin; direction of the outer surfaces of the teeth

facial nerve mixed sensory and motor cranial nerve (CN VII) that innervates the scalp, forehead, eyelids, muscles of facial expression, platysma muscle, posterior digastric muscle, stylohyoid muscle, lip, chin, and nose muscles, submaxillary and

- submandibular salivary glands, and the afferent fibers from taste buds of the anterior two-thirds of the tongue
- facial plane.** See Frontal plane.
- facial tic** any spasmodic movement or twitching of the face
- facilitation** intensification of response; diminished nerve tissue resistance after passage of an impulse so that a second stimulus will evoke a reaction more easily. *Ant:* Inhibition.
- factitious disorder** mental disorder characterized by the compulsive, voluntary production of signs and symptoms of a disease for the sole purpose of assuming a patient role and in the absence of other secondary gain
- falx cerebelli** a small fascial membrane extending from the tentorium cerebelli to the posterior cranial cavity; it attaches posteriorly to the internal occipital crest and margins of the occipital sinus
- fascia** fibrous band or sheath of collagenous connective tissue that encloses muscles and certain organs and separates them subcutaneously into various groups
- fascicle.** See Muscle compartment.
- fasciculation** involuntary contraction of a group of muscle fibers supplied by a single nerve fiber; a coarser form of muscle contraction than fibrillation
- fibrillation** spontaneous, involuntary contraction of individual muscle fibers
- fibrocartilage** type of cartilage characterized by a large amount of fibrous tissue in the cartilage matrix and an ability for adaptive remodeling; found in the intervertebral discs, pubic symphysis, mandibular symphysis, sternoclavicular joint, and certain regions of the TMJ
- fibrocartilaginous joint.** See Symphysis.
- fibromyalgia (FM)** characterized by widespread body pain, multiple tender points over the body, poor sleep, stiffness, and generalized fatigue
- fibrosarcoma** sarcoma that contains fibrous connective tissue
- fibrosis** formation of fibrous connective tissue to replace normal tissue lost through injury or infection
- fibrositis** misnomer. See Fibromyalgia.
- fibrous** composed of or containing fibers of connective tissue
- fibrous dysplasia** abnormal fibrous replacement of bone marrow with onset usually during childhood
- filiform** thread-shaped or extremely slender
- first-bite syndrome** pain in the parotid (salivary) gland or mandibular region at the first bite that subsequently improves with each bite; the cause is unclear but may be related to nerve impairment from surgery or other conditions
- flat-plane appliance** misnomer. See Stabilization appliance.
- flexion** a motion that reduces the joint angle; the act of bending or the condition of being bent. *Ant:* Extension.
- flexion-extension injury** traumatic, sudden, exaggerated movement of joints through the extremes of their range of motion in hyperflexion and then hyperextension, resulting in ligamentous sprain, muscular strain, inflammation, and subsequent reflex muscle splinting
- fluoroscopy** radiographic technique providing immediate dynamic images for visualizing the contours and function of a deep structure such as an organ or joint
- focal** highly localized
- focal plane tomography.** See Tomography: focal plane.
- foraminal encroachment** stenosis of the opening for the passage of the spinal nerve from the spinal cord to the periphery. *Syn:* Foraminal stenosis.
- fos** the cellular analog of a viral oncogene, which is composed of genetic protein within a cell (c-fos), designed to prevent abnormal growth leading to cancer; cellular oncogenes function as a molecular marker of pain in that their presence within the nociceptive transmission system is induced by noxious stimulation; also called proto-oncogene, representative of normal genetic expression
- fossa** [*pl:* fossae] hollow pit, concavity, or depression, especially on the surface of the end of a bone or a tooth. *Syn:* Fovea.
- fovea.** See Fossa.

fracture a break or rupture of a part, especially a bone

freeway space interocclusal distance or separation between the dental arches when the mandible is in its rest position

fremitus vibration, especially when palpable

frontal plane vertical plane, perpendicular to the sagittal plane, dividing the body into front to back portions. *Syn:* Coronal plane, Facial plane.

functional mandibular disorder a disorder relating to abnormal mandibular movements or actions

functional mandibular movement a natural, proper, or characteristic movement or action of the mandible made during speech, mastication, yawning, swallowing, respiration, and other proper activities

fungiform mushroom-shaped or bulbous

G

gamma knife surgery precisely focused radiation of 40 to 90 Gy emitted from 201 photon beams applied to the trigeminal root entry zone. *Syn:* Stereotactic neurosurgery, Stereotactic radiosurgery.

ganglion a collection or mass of nerve cells serving as a center of nervous influence

generalized anxiety disorder (GAD) disorder characterized by persistent and excessive uncontrolled feelings of anxiety or worry for a period of 6 months or longer accompanied by at least three of the following symptoms: restlessness, fatigue, difficulty concentrating, irritability, muscle tension, and sleep disturbance, and not associated with another mental disorder, substance use, or medical condition³

genetic pertaining to reproduction, birth, origin, or heredity

geniculate neuralgia. *See* Neuralgia: geniculate.

genioplasty plastic surgery of the chin

geographic tongue occasionally symptomatic, inflammatory disorder of the tongue mucosa characterized by multiple, well-demarcated zones of erythema located on the dorsum and lateral border of

the tongue. *Syn:* Benign migratory glossitis, Erythema migrans.

giant cell arteritis. *See* Arteritis.

Gilles de la Tourette syndrome. *See* Tourette syndrome.

ginglymoarthrodial joint paired joint like the TMJ that is both a hinged (ginglymoid) and a gliding (arthrodial) joint

ginglymoid joint hinging joint with one convex and one concave surface, with movement in only one plane of space

gliding of condyle. *See* Translation of condyle.

globus the feeling that there is a lump in the throat without the presence of a physical object

glossalgia. *See* Glossodynia.

glossodynia painful or burning tongue. *Syn:* Glossalgia.

glossopharyngeal nerve mixed cranial nerve (CN IX) carrying somatosensory information from the posterior pharyngeal tissues and somatosensory and taste information from the posterior one-third of the tongue; the motor fibers supply the pharyngeal muscles

glossopharyngeal neuralgia. *See* Neuralgia: glossopharyngeal.

glossopyrosis burning tongue

gnathic pertaining to the jaw or cheek

gnathologic pertaining to the science of the dynamics of the jaws

gout disorder of purine metabolism characterized by hyperuricemia and the deposition of monosodium urate crystals in joints, resulting in acute attacks of arthritis with red, hot, and swollen joints, especially the big toe; gout occurs primarily in men older than 30 years. *Syn:* Arthritis urica.

grating joint sound. *See* Crepitation.

grinding of teeth. *See* Bruxism.

H

hard tissue relatively rigid skeletal tissue including bone, hyaline cartilage, and fibrocartilage

headache pain or ache in the head. *Syn:* Cephalalgia.

headache attributed to TMD pain located in the temple with provocation testing of the

- temporalis muscle(s) replicating the headache and a temporal relationship to any pain-related TMD; jaw movement, function, or parafunction affects the headache
- hemarthrosis** bloody effusion into cavity of a joint
- hematoma** swelling or mass of blood confined to a tissue or space
- epidural h.** collection of blood in epidural space due to damage and leakage of blood from the middle meningeal artery
- subdural h.** collection of blood in subdural space from laceration of the brain or rupture of the bridging veins
- hemifacial microsomia** condition in which one side of the face is abnormally small and underdeveloped, yet normally formed
- hemifacial spasm** involuntary unilateral sudden contraction of the muscles in the facial nerve distribution
- hemiparesis** unilateral muscular weakness or paralysis
- hemiplegia** loss of motor function and sensation on one side of the body
- hemorrhage** abnormal internal or external discharge of blood; bleeding
- herpes zoster** varicella zoster virus infection of the cranial or spinal nerve ganglia and cutaneous areas they supply, causing acute inflammation, characterized by painful vesicular skin or mucosal eruptions. *Syn:* Zoster. *Misnomer:* Shingles.
- heterogenous** derived from different sources
- heterophoria** deviation of an eye only when it is covered
- heterotopic pain** pain occurring at a site different from that of the cause
- heterotropia** a constant lack of parallelism of the visual axes of the eyes. *Syn:* Strabismus.
- high condylectomy** surgical removal of only a portion of the superior mandibular condyle
- histaminic cephalalgia.** *See* Cluster headache.
- histochemical** pertaining to the chemical substances in the body tissues on a cytologic scale
- histology** anatomical study of the minute structure, composition, and function of the tissues
- history of present illness (HPI)** narrative report of each symptom or complaint, including the onset, duration, and character of the present illness
- holocephalic headache** headache that is felt in the entire head; from Greek *holos* (entire) and *cephale* (head)
- homogenous** having a similar structure or characteristic
- homolateral.** *See* Ipsilateral.
- homologous** corresponding or alike in critical attributes such as structure, position, and origin, but not necessarily function
- horizontal plane.** *See* Transverse plane.
- Horner syndrome** neurologic condition characterized by a small pupil and ptosis on the side of the headache. *Syn:* Oculosympathetic paresis.
- Horton headache.** *See* Cluster headache.
- Horton syndrome.** *See* Cluster headache.
- humoral** relating to or arising from any of the body fluids
- hyaline cartilage** type of cartilage found on the articular surfaces of most bones, characterized by flexibility, glasslike appearance, and network of connective tissue fibers; forms a template for endochondral bone formation
- hydrocephalus** an excessive accumulation of cerebrospinal fluid in the brain, causing cerebral ventricular dilation, elevated intracranial pressure, and enlargement of the skull
- hypalgesia** diminished sensibility to pain. *Syn:* Hypoalgesia.
- hyperactivity** exaggerated amount of functional movement
- hyperacusis** painful or abnormally acute sensitivity to sound
- hyperalgesia** an increased response to a stimulus that is normally painful¹
- primary h.** *See* Primary hyperalgesia.
- secondary h.** *See* Secondary hyperalgesia.
- hyperesthesia** increased sensitivity to stimulation, excluding the special senses¹
- hyperextension** extreme extension of a limb or joint
- hyperextension-hyperflexion injury.** *See* Flexion-extension injury.
- hyperflexion** extreme flexion of a limb or joint

hyperfunction of muscle excessive function of muscle

hypermobility excessive mobility; defined by extreme ranges of joint movement or laxity in a specific minimal number of defined joints. *Syn:* Hypermobility syndrome (misnomer); *Ant:* Hypomobility.

monoarticular h. involving only one joint

oligoarticular h. involving two to four joints

polyarticular h. hypermobility involving more than four joints

hyperpathia a painful syndrome characterized by an abnormally painful reaction to a stimulus, especially a repeated stimulus, as well as an increased threshold¹

hyperplasia overdevelopment of tissue or structure with an increase in the number of normal cells in a normal arrangement

hypertonicity of muscle excess muscular tonus, tension, or activity

hypertranslation excessive or exaggerated gliding movement range of a body part, such as the mandibular condyle

hypertrophic arthritis. *See* Osteoarthritis.

hypertrophy increase in size of an organ or structure but not in the number of its constituent cells. *Ant:* Atrophy.

hyperuricemia abnormal amount of uric acid in the blood, found in gout but also in many other conditions

hypesthesia. *See* Hypoesthesia.

hypoalgesia diminished pain in response to a normally painful stimulus.¹ *See* Hypalgesia.

hypochondriasis somatoform disorder marked by the preoccupation with and anxiety over one's health, with exaggeration of normal sensations and misinterpretation of normal physical signs and minor complaints as serious illness or disease

hypoesthesia decreased sensitivity to stimulation, excluding the special senses.¹ *Syn:* Hypesthesia.

hypogeusia diminished sensibility to taste

hypoglossal nerve mixed cranial nerve (CN XII) carrying afferent proprioceptive impulses as well as efferent motor impulses to the intrinsic and extrinsic muscles of the tongue, with communication to the vagus nerve (CN X)

hypomobility reduced or restricted range of motion. *Ant:* Hypermobility.

hypoplasia incomplete or defective development or underdevelopment of a tissue or structure; implies fewer than the usual number of cells

hypoxia deficiency of oxygen

hysteria. *See* Somatic symptom disorder.

hysterical trismus severe restriction of mandibular motion due to acute psychologic distress

iatrogenic condition caused by medical personnel during examination, diagnostic tests, or treatment procedures

idioglossia imperfect articulation with meaningless vocalization

idiopathic of unknown etiology

idiopathic continuous neuropathic pain constant unremitting pain from dysfunction in the nervous system without obvious pathology and of unknown etiology

idiopathic odontalgia. *See* Persistent idiopathic facial pain.

idiopathic pain painful disease or disorder without obvious pathology and of unknown etiology

illness condition characterized by a pronounced deviation from a normal healthy state

illness behavior alterations in behavior in response to an actual or perceived illness

imaging hard-record representation or visual reproduction of a structure for the purpose of diagnosis, including radiographs, ultrasound, computed tomography, and magnetic resonance imaging

impairment a medical determination of the amount of deterioration from a state of normal health; a measure of the loss of use or abnormality of psychologic, physiologic, or anatomical structure or function

incidence number of new cases of a condition that occur during a specified period of time; compare with prevalence

incoordination inability to move in a smooth, controlled, symmetric, and harmonious motion

infarct area of tissue necrosis following cessation or interruption of blood supply

infection invasion of a tissue by pathogenic microorganisms that reproduce and multiply, causing disease by local cellular injury, secretion of toxin, or antigen-antibody reaction in the host

infectious arthritis acute inflammatory condition of a joint caused by bacterial or viral infection

inferior. *Ant:* Cephalad, Superior. *See* Caudal.

inferior retrodiscal lamina the most inferior border of the retrodiscal tissues or posterior attachment; this tissue is predominantly dense fibrous connective tissue and functions as a ligament to restrict anterior rotation of the disc on the condyle

inflammation protective normal response of tissue to irritation or injury, characterized by redness, heat, swelling, and pain

inhibition suppression or arrest of a process

initiating factors factors that cause the onset of a disease or disorder

insidious onset development of a disorder that is gradual, subtle, or imperceptible. *Ant:* Acute onset.

insomnia abnormal wakefulness or inability to sleep during the period when sleep should occur

interceptive occlusal contact. *See* Supracontact.

intercuspal position (ICP) the complete intercuspatation of the opposing teeth independent of condylar position, sometimes referred to as the best fit of the teeth regardless of the condylar position.² *Syn:* Centric occlusion, Maximal intercuspal position, Maximal intercuspatation.

intercuspatation the proximity of cusps of opposing teeth.² *Syn:* Interdigitation.

maximal i. *See* Intercuspal position.

interdigitation. *See* Intercuspatation.

interdisciplinary the coordinated effort of two or more professions building on each other's expertise to achieve an individualized care plan

internal inside the body or within a structure. *Ant:* External.

internal derangement disturbed arrangement of intracapsular joint parts causing in-

terference with smooth joint movement; in the TMJ it can relate to elongation, tear, or rupture of the capsule or ligaments, causing altered disc position or morphology

interocclusal between the opposing dental arches

interocclusal appliance an intraoral device that provides an artificial occlusal surface, designed to fit over either the maxillary or mandibular teeth

interstitial pertaining to the space between tissues

intra-arch within either the mandible or the maxilla

intra-articular located within a joint

intra-articular disc. *See* Disc: intra-articular.

intracapsular located within the capsule of a joint. *Ant:* Extracapsular.

intracapsular adhesion. *See* Adhesion: intracapsular.

intracondylar within the condyle

intracranial within the cranium or skull. *Ant:* Extracranial.

intractable resistant to treatment

intrameatal within the auditory canal or meatus

intraoral within the oral cavity

intrathecal drug infusion medication delivered directly to the intrathecal space through a small catheter; because the drug is delivered directly to the spinal cord, a smaller dose is required, which helps minimize systemic side effects

intrinsic originating from or situated entirely within an organ, tissue, or part. *Ant:* Extrinsic.

intrinsic trauma. *Ant:* Extrinsic trauma. *See* Trauma: microtrauma.

intrusion inward projection; movement of the tooth in an apical direction

ionizing radiation radiation created by displacing negatively charged electrons from atoms by the application of an electrical current

iontophoresis introduction of ions of soluble salts into tissues through intact skin by means of direct electric current

ipsilateral pertaining to the same side. *Syn:* Homolateral; *Ant:* Contralateral.

ischemia local and temporary inadequate blood supply to a specific organ or tissue

isokinetic exercises dynamic muscle activity performed at a constant angular velocity

isometric exercises active exercise performed against stable resistance without change in the length of the muscle

isotonic exercises active exercise that shortens the muscle without appreciable change in the force of muscle contraction

J

jaw either the maxilla or mandible

jaw tracking. See Mandibular movement recording.

j.t. devices instruments used to quantify mandibular movements

joint the place of union or junction between two or more bones

juvenile rheumatoid arthritis (JRA) idiopathic arthritis that begins before the age of 16 years, with rheumatoid factor found in 70% of cases; more common in girls, with onset most often between ages 12 and 15 years. *Syn:* Still disease.

juxtaposed positioned adjacently or in apposition

K

kinesiograph instrument used to record and provide graphic representation of movement

kinesiography used to detect and record three-dimensional motion of the mandible. See Mandibular movement recording.

kinesiology the science or study of human movement

kinetic pertaining to, characterized by, or producing motion

L

labial of, pertaining to, or toward the lip

labioversion condition of being displaced labially from the normal line of occlusion

lacrimation secretion of tears by the lacrimal glands

larynx musculocartilaginous structure lined with a mucous membrane, located below the dorsal root of the tongue and the hyoid bone at the top of the trachea; the organ of voice

latent disease dormant condition existing as a potential disorder

lateral away from the midline of the body; to the side. *Ant:* Medial.

lateral excursion of mandible. See Laterotrusion of mandible.

laterotrusion of mandible movement of the mandible away from the median or toward the side

lavage the process of washing out or irrigating a cavity or an organ

leaf gauge set of blades used to provide a metered separation or measure of the distance between two parts, such as the incisors

leptoprosopic having a facial form that is long, narrow, and protrusive

leukocytosis increase in the number of circulating white blood cells

lichen planus an inflammatory skin disease with wide, flat, irregular, often persistent circumscribed papules, with keratotic plugging

ligament flexible band of fibrous tissue, slightly elastic and composed of parallel collagenous bundles, binding joints together and connecting various bones and cartilages

l. laxity excessive looseness in ligamentous attachment

lingual of, pertaining to, or toward the tongue

loading, joint increasing the compressive force on a joint

local myalgia pain in a muscle with location of the pain only at the site of palpating finger(s); a subcategory of myalgia

locking of joint misnomer. See Disc displacement: without reduction with limited opening.

longitudinal plane. See Sagittal plane.

low-level laser therapy (LLLT) nonthermal therapy using a laser light in the red or infrared range

lupus erythematosus. See Systemic lupus erythematosus.

luxation a condition in which the disc-condyle complex is anterior to the articular eminence and is unable to return to the mandibular fossa without a maneuver by a clinician. *Syn:* Open lock.

lys- [prefix] break apart

lysis dissolution, decomposition, or loosening of tissues

lytic pertaining to lysis

M

macroglossia excessive tongue size

macrotrauma. *See* Trauma: macrotrauma.

magnetic resonance imaging (MRI) non-invasive, nonionizing imaging method that uses the signals from resonating hydrogen nuclei after they have been subjected to a charge in a magnetic field; their relaxation and resultant resonant frequency is detected, measured, and converted by a computer into an image

malformation failure of proper or normal development, a primary structural defect, or deformity that results from a localized error of morphogenesis

malinger to voluntarily feign or exaggerate an illness, usually to deliberately escape responsibility, provoke sympathy, or gain compensation; deliberate attempt to deceive in the absence of any psychiatric disorder

malocclusion. *See* Occlusal variation.

mandible horseshoe-shaped lower jawbone, consisting of the horizontal body joined at the symphysis and two vertical rami with the anterior coronoid process and the posterior condylar process, separated by the mandibular notch; the superior border of the body, the alveolus, contains sockets for the mandibular teeth

mandibular pertaining to the mandible

mandibular movement recording kinesiographic recording of the movement of the mandible

mandibular nerve the third division of the trigeminal nerve, which leaves the skull through the foramen ovale and provides motor innervation to the muscles of mastication, the tensor veli palatini, the tensor

tympani, and the anterior belly of the digastric and mylohyoid muscles; it provides the general sensory innervation to the teeth and gingiva, the mucosa of the cheek and floor of the mouth, the epithelium of the anterior two-thirds of the tongue, the meninges, and the skin of the lower portion of the face

mandibular orthopedic repositioning appliance (MORA) an interocclusal appliance that covers only the posterior mandibular teeth to temporarily alter the mandibular position

mandibular trismus. *See* Trismus.

Marfan syndrome autosomal-dominant connective tissue disorder, characterized by abnormal length of extremities, cardiovascular abnormalities, and other deformities

mastication process of chewing food in preparation for deglutition

masticatory muscles muscles responsible for masticatory motion, including the paired masseter, temporalis, lateral pterygoid, and medial pterygoid muscles

masticatory pain pain or discomfort about the face and mouth induced by chewing or other use of the jaws but independent of local disease involving the teeth and the mouth

maxilla paired upper jawbone that inferiorly forms the palate and the alveolus with the upper teeth, superiorly forms part of the orbit, and medially creates the walls of the nasal cavity

maxillary pertaining to the maxilla

maxillofacial pertaining to the maxillary and mandibular dental arches and the face

maxillomandibular pertaining to the maxilla and mandible

maximal intercuspal position. *See* Intercuspal position.

maximal intercuspation. *See* Intercuspal position.

medial toward the midline of the body. *Ant:* Lateral.

mediate auscultation listening to sounds with the use of an instrument

mediation bringing about a result, conveying an action, communicating information, or serving as an intermediary

mediotrusion movement of the mandible medially

mediotrusion of mandible movement of the mandible toward the median or center

medullary dorsal horn. See Spinal trigeminal nucleus.

meniscectomy, TMJ misnomer. See Discectomy.

meniscus crescent-shaped fibrocartilaginous structure found in some synovial joints but not in the TMJ

meniscus, TMJ misnomer. See Disc: intra-articular.

mental disorder a disorder of cognition, affect, or behavior that impairs adaptive functioning that may be of organic or psychologic origin

mesencephalic nucleus a nucleus located at the mesopontine junction that contains cell bodies of primary afferent proprioceptors that innervate the jaw-closing muscles (masseter, temporalis and medial pterygoid) and the periodontium

mesial toward the median sagittal plane of the face following the curvature of the dental arch

mesocephalic having a head shape that is neither long nor short, narrow nor wide, oval nor rounded

mesoprosopic having a facial form that is neither long nor short, narrow nor broad, protrusive nor flat

metaboreceptor receptor that responds to an increase in metabolic products

metaplasia conversion of one tissue type into a form that is not normal for that tissue

metastatic shifting of a disease or its manifestation from one part of the body to another; in cancer, the appearance of neoplasms in parts of the body remote from the seat of the primary tumor

microglossia abnormally small tongue

micrognathia abnormal smallness of the jaw, especially the mandible

microstomia abnormally small mouth

microtrauma. See Trauma: microtrauma.

midline of teeth interproximal contact zone between the central incisor teeth of the maxillary or mandibular dental arch

migraine periodic, recurrent, intense throbbing headache, frequently unilateral and often accompanied by phonophobia, photophobia, and nausea or vomiting and aggravated by routine physical activity; classified by descriptive characteristics rather than by known physiologic mechanisms

chronic m. migraine occurring for at least 15 days per month for more than 3 months, not related to medication overuse

classic m. See M. with aura.

common m. See M. without aura.

hemiplegic m. headache associated with oculomotor nerve palsy and partial to complete unilateral paralysis of motor function

m. with aura headache with associated premonitory sensory, motor, or visual symptoms (prodrome). Previously used term: Classic migraine.

m. with brainstem aura disturbance of brainstem function with dramatic but slowly evolving neurologic events, often involving total blindness, altered consciousness, confusional states, and subsequent headache

m. without aura condition in which no focal neurologic disturbance precedes the headache but all other migraine with aura characteristics are the same. *Syn:* Common migraine.

probable m. migraine-like headache not completely fulfilling all criteria for migraine headache

retinal m. repeated attacks of monocular scotoma or blindness lasting less than 1 hour and associated with headache; normal findings on examination and MRI or CT

transformed m. headache that changes from episodic to daily

miosis pupillar contraction

mixed connective tissue disease. See Connective tissue: disorders.

mobilization, joint the process of restoring motion to a joint

mononeuropathy neuropathy in a single nerve, also called mononeuritis

monosynaptic reflex simplest and fastest reflex involving one motor and one sensory neuron with one synapse; eg, muscle stretch reflex

mood disturbance persistent disturbance of the emotional state

morphology form or structure of an organism

motor neuron neuron carrying efferent impulses that initiate muscle contraction

mouth guard plastic intraoral appliance that covers and protects the teeth during contact sports

MRI. See Magnetic resonance imaging.

multidisciplinary use of multiple specialties building individual care goals based on their area of expertise

multifactorial resulting from the combined action of several factors

multiple myeloma malignant neoplasm of bone marrow

multiple sclerosis (MS) chronic, slowly progressive disease of the central nervous system of unknown etiology, characterized by demyelinated glial patches called plaques

muscle tissue composed of contractile fibers that effect movements of an organ or part of the body; muscle types include striated skeletal and cardiac muscles and smooth nonstriated visceral muscles

digastric m. originates on the digastric notch of the mastoid process and inserts on the mandible near the symphysis; raises the hyoid bone and base of the tongue and depresses the mandible

lateral (external) pterygoid m. muscle with two heads, with a single origin on the lateral pterygoid plate and greater wing of the sphenoid; insertion is on the fovea of the condyle and capsule of the TMJ, and the other insertion may be partially on the intra-articular disc; this muscle of mastication translates the mandible and is active in mouth opening and near-final mouth closure

masseter m. superficial masseter originates on the zygomatic process and arch and inserts on the ramus and the angle of the mandible; the deep masseter originates on the zygomatic arch and inserts on the upper half of the ramus and the

coronoid process of the mandible; powerful muscle of mastication that elevates the mandible

medial pterygoid m. originates on the maxillary tuberosity and medial surface of the lateral pterygoid plate and inserts on the medial surface of the ramus and angle of the mandible; during mastication, elevates and protrudes the mandible and, during speech, is active in mandibular movements

scalene m. these three muscles originate on the transverse process of the cervical vertebrae and insert on the ribs; act to stabilize the cervical vertebrae or incline the neck to the side and are accessory muscles to respiration

sternocleidomastoid m. muscle with two heads, one originating on the sternum and the other on the clavicle, and inserting onto the mastoid process and superior nuchal line of the occipital bone; rotates and extends the head and flexes the vertebral column

suboccipital m. muscles situated below the occipital bone that act to stabilize the cervical vertebrae and head position and to extend or rotate the head and neck

suprahyoid m. digastric, geniohyoid, mylohyoid, and stylohyoid; all attach to the upper part of the hyoid bone and act to stabilize and elevate the hyoid bone and depress the mandible

temporalis m. fan-shaped muscle with its origin on the temporal fossa and insertion on the coronoid process and anterior aspect of the ramus; elevates and retrudes the mandible during mastication

trapezius m. originates on the superior nuchal line of the occipital bone and spinous process of the seventh cervical and all of the thoracic vertebrae and inserts on the clavicle and scapula; elevates the shoulder and rotates the scapula

muscle compartment muscle bundle enclosed within a single sheath. *Syn:* Fascicle.

muscle compartment syndrome pain and stiffness in a muscle due to oxygen deprivation within the muscle compartment

acute m.c.s. oxygen deprivation due to capillary compression from an acute increase in volume in the muscle compartment secondary to fracture, edema, or bleeding

chronic m.c.s. oxygen deprivation during muscle contractions secondary to reduced muscle relaxation time between contractions

muscle contraction the shortening or development of tension in muscle

muscle contracture. *See* Contracture.

muscle cramp misnomer. *See* Spasm, muscle.

muscle hypertonia increased tone of skeletal muscle or increased resistance to passive stretch

muscle hypertonicity. *See* Muscle hypertonia.

muscle relaxation appliance misnomer. *See* Stabilization appliance.

muscle splinting. *See* Protective muscle splinting.

muscular dystrophy group of genetically transmitted diseases characterized by progressive atrophy of symmetric groups of skeletal muscles without evidence of degeneration of neural tissue

musculoskeletal relating to the muscles (including fascial sheaths and tendons) and joints

musculoskeletal pain deep somatic pain that originates in skeletal muscles, fascial sheaths, and tendons (myogenous pain), bones and periosteum (osseous pain), joint, joint capsules, and ligaments (arthralgic pain), and in soft connective tissues

myalgia pain in a muscle affected by jaw movement, function, or parafunction, and replication of this pain with provocation testing

myelin lipid that forms a major component of the sheath that surrounds and insulates the axon of some nerve cells

myelomeningocele a congenital developmental defect of the neural tube causing a malformation or incomplete closure; also

known as spina bifida; most commonly occurs in the lumbosacral region

myelopathy functional disturbance or change in the spinal cord

myoclonus clonic spasm or twitching that results from the contraction of one or more muscle groups

myofascial pertaining to muscle and its attaching fascia

myofascial pain pain in a muscle as described by myalgia with pain spreading beyond the location of the palpating finger(s) but within the muscle; a subcategory of myalgia

myofascial pain dysfunction syndrome misnomer. *See* Myalgia.

myofascial pain with referral pain in a muscle as described by myalgia with pain referred beyond the muscle; a subcategory of myalgia

myofascial trigger point hyperirritable spot, usually within a taut band of skeletal muscle or in the muscle fascia, that is painful on compression and can give rise to characteristic referred pain, tenderness (secondary hyperalgesia), and autonomic phenomena; subdivided into active and latent

active m.t.p. myofascial trigger point responsible for local or referred current pain or symptoms without stimulation through palpation

latent m.t.p. myofascial trigger point with all the characteristics of an active myofascial trigger point, including referred pain with palpation, but not currently causing spontaneous clinical pain or symptoms

myofascitis inflammation of muscle and its fascia

myofibrosis replacement of muscle tissue by fibrous tissue

myofibrositis inflammation of the perimysium, the connective tissue separating individual muscle fascicles

myofunctional therapy use of exercises to improve the function of a group of muscles

myogenous of muscular origin

myogenous pain deep somatic musculoskeletal pain originating in the skeletal muscles, fascial sheaths, or tendons

myositis pain in a muscle with clinical characteristics of inflammation or infection, ie, edema, erythema, and/or increased temperature

myositis ossificans ossification of muscle tissue, usually after injury

myxoma neoplasm derived from primitive connective tissue, composed of a stoma-resembling mesenchyme

N

narcotic any drug that produces sleep, insensibility, or stupor; more commonly, opium or any of its derivatives (morphine, heroin, codeine, etc)

natural history of disorder natural sequence, duration, transitional stages, and nature of change of a disease or disorder over time, without external interference such as trauma or treatment

neck-tongue syndrome rare disorder characterized by infrequent short-lasting attacks of unilateral pain in the upper neck radiating toward the ear and associated with numbness, paresthesia, or the sensation of involuntary movement of the ipsilateral half of the tongue

necrosis tissue death

negative predictive value (NPV) measure of the probability that a person does not have the disease, given a negative result

neoplasm abnormal, uncontrolled, progressive growth of new tissue; designated as benign or malignant. *Syn:* Tumor.

nerve a cordlike structure, made up of numerous nerve fibers, that conveys impulses from one part of the body to another

nerve block injection of local anesthetics or steroids into the epidural space for extended pain relief

nervus intermedius smaller root of the facial nerve that merges with the facial nerve at the level of the geniculate ganglion and innervates the lacrimal, nasal, palatine, submandibular, and sublingual glands and the anterior two-thirds of the tongue

neural pertaining to one or more nerves

neural pathway the nerve structures through which an impulse is conducted

neuralgia paroxysmal or constant pain, typically with sharp, stabbing, shooting, electric-like, itching, or burning character, in the distribution of a nerve or nerves

auriculotemporal n. paroxysmal pain with refractory periods involving the auriculotemporal branch of the trigeminal nerve

cranial n. neuralgia along the course of a cranial nerve

geniculate n. painful disturbance of the sensory portion of the facial nerve characterized by lancinating pain in the middle ear and the auditory canal. *Syn:* Nervus intermedius neuralgia, Ramsay Hunt syndrome.

glossopharyngeal n. severe, paroxysmal, lancinating pain due to a lesion in the petrosal and jugular ganglion of the glossopharyngeal nerve (CN IX) that radiates to the throat, ear, teeth, and tongue and is triggered by movement in the tonsillar region by swallowing or coughing; branches to the carotid artery can trigger a vasovagal response, including altered respiration, blood pressure, and cardiac output; rare, unilateral condition; usually in men older than 50 years

nervus intermedius n. See Geniculate n.

occipital n. neuralgia involving the greater occipital nerve (C2 or C3)

postherpetic n. neuralgia following outbreak of the herpes zoster virus

postsurgical n. pain of neuralgic character secondary to inadvertent damage to sensory nerves during a surgical procedure

pretrigeminal n. syndrome of dull aching or burning pain, often in the oral cavity or teeth, which precedes true paroxysmal trigeminal neuralgia; pain duration varies widely from hours to months, with variable periods of remission; onset of true neuralgic pain may be quite sudden

superior laryngeal n. condition characterized by sharp, paroxysmal, unilateral submandibular pain that may radiate to the ear, eye, or shoulder, a distribution indistinguishable from glossopharyngeal neuralgia; the superior laryngeal nerve is

a branch of the vagus nerve (CN X) and innervates the cricothyroid muscle of the larynx

traumatic n. deafferentation pain secondary to disruption of normal sensory pathways from traumatic or surgical injury

trigeminal n. (TN) disorder of the sensory divisions of the trigeminal nerve (CN V), characterized by recurrent paroxysms of sharp, stabbing pains in the distribution of one or more branches of the nerve, often precipitated by stimulation of specific trigger zones. *Syn:* Tic douloureux.

neurasthenia syndrome of chronic mental and physical fatigue and weakness; term virtually obsolete in Western medicine

neurectomy peripheral ablative procedure in which the offending trigeminal nerve branch is avulsed under local or general anesthesia

neuritis inflammation of a nerve or nerves¹

neuroablative procedures irreversible procedures performed to interrupt sensory pathways to the brain or in the brainstem by severing or destroying the appropriate pathology; examples include cordotomy, rhizotomy, thalamotomy, or chemical destruction of neural structures

neuroaugmentation use of medications or electrical stimulation to supplement activity of the nervous system

neurogenic pain pain initiated or caused by a primary lesion, dysfunction, or transitory perturbation in the peripheral or central nervous system.¹ *Syn:* Neuropathic pain.

neurogenous. See Neuropathic pain.

neuroleptosis altered state of consciousness characterized by quiescence, reduced motor activity, anxiety, and indifference to surroundings, induced by a neuroleptic medication

neuroleptic drug with antipsychotic properties

neurologic pertaining to the nervous system and its disorders

neurolysis longitudinal surgical incision to free a nerve sheath, surgical loosening of fibrous nerve adhesions, or destruction of nerve tissue

sympathetic n. See Sympathectomy.

neuromodulation a group of medical therapies that use drugs or electricity to regu-

late pain or minimize dysfunction, including drug pumps and neurostimulation

neuromuscular concerning both nerves and muscles

neuron nerve cell

neuropathic pertaining to neuropathy

neuropathic pain pain initiated or caused by a primary lesion or dysfunction in the nervous system. *Syn:* Neurogenic pain.

neuropathy disturbance of function or pathologic change in a nerve; in one nerve, mononeuropathy; in several nerves, mononeuropathy multiplex; if diffuse and bilateral, polyneuropathy¹

neuroplasticity dynamic ability of the central nervous system to alter central processing of impulses secondary to ongoing afferent impulses usually thought to be nociceptive

neurostimulation low-level electrical pulses delivered by an implanted pacemaker-type device that stimulate various tissues of the nervous system, including the spinal cord, peripheral nerves, and brain

neurotransmitter any biochemical substance that mediates the passage of an impulse across the synapse from one nerve cell to another

neurovascular concerning both the nervous and vascular systems

nightguard appliance misnomer. See Interocclusal appliance.

NMRI nuclear magnetic resonance imaging. See Magnetic resonance imaging.

nocebo negative treatment effects induced by a substance or procedure containing no toxic or detrimental substance

nociception stimulation of specialized nerve endings designed to transmit information to the central nervous system concerning potential or actual tissue damage

nociceptive capable of receiving and transmitting painful sensation

nociceptive pain pain resulting from tissue damage and the subsequent release of chemicals that act as noxious stimuli and are perceived by the brain as pain; also called somatic pain

nociceptive pathway an afferent neural pathway that transmits pain impulses to the central nervous system

nociceptor a specialized nerve ending that senses painful or harmful sensations

primary afferent n. one of three major groups of peripheral nerves capable of transmitting the presence of a noxious stimulus to the skin or the spinal cord; these include the A β mechanosensitive nociceptors, the A δ mechanothermal nociceptors, and the unmyelinated C-polymodal nociceptors

nocturnal pertaining to or occurring in the hours of darkness. *Ant:* Diurnal.

noma rapidly progressive necrotizing infection of the mouth and face usually seen in malnourished children; may also affect immunocompromised individuals

noninnervated tissue that is lacking in sensory or motor nerve supply

noninvasive denoting diagnostic or therapeutic procedures that do not require penetrating the skin or entering a cavity or organ of the body

nonodontogenic toothache pain presenting as a toothache but originating from a source other than dental and periodontal tissues

nonreducing disc. *See* Disc displacement: without reduction.

nonrestorative sleep. *See* Sleep: nonrestorative.

nonsteroidal anti-inflammatory drugs (NSAIDs) class of anti-inflammatory medications that also provide analgesia but lack the detrimental side effects associated with steroid use

noradrenalin. *See* Norepinephrine.

norepinephrine biogenic amine released as a hormone by the adrenal medulla that acts as a neurotransmitter in the central nervous system and the sympathetic nervous system; differs from epinephrine in the absence of an N-methyl group

norepinephrinergic relating to any drug that stimulates the production of norepinephrine

noxious stimulus a stimulus that is potentially or actually damaging to tissues

nuchal line bony ridge at the nape or back of the skull

nuchal rigidity resistance to flexion of the neck; often seen in meningitis

O

occipital pertaining to the back of the head

occlude bringing the maxillary and mandibular teeth together; obstruct or close off

occlusal pertaining to the masticatory surfaces of teeth

occlusal adjustment. *See* Occlusal equilibration.

occlusal appliance. *See* Interocclusal appliance.

occlusal contact. *See* Occlusion.

occlusal equilibration irreversible adjustment of the coronal portion of the tooth by abrasive instruments, usually to more evenly distribute the vertical and excursive forces of occlusion

occlusal interference. *See* Supracontact.

occlusal splint. *See* Interocclusal appliance.

occlusal trauma injury to the periodontium resulting from occlusal forces in excess of the reparative capacity of the attachment apparatus; contrast with primary occlusal trauma, secondary occlusal trauma. *Syn:* Occlusal traumatism, Periodontal trauma, Periodontal traumatism.

occlusal traumatism. *See* Occlusal trauma.

occlusal variation unusual biologic or functional relationship between the maxillary and mandibular teeth

occlusal vertical dimension. *See* Vertical dimension of occlusion.

occlusal wear. *See* Attrition.

occlusion the act or process of closure or of being closed or shut off; the static relationship between the incising or masticating surfaces of the maxillary and mandibular teeth or tooth analogs

ocular pertaining to the eye

oculomotor nerve cranial nerve (CN III) arising in the midbrain and supplying the levator palpebrae, superior rectus, recti, and inferior oblique muscles of the eye; the sphincter pupillae and ciliary muscles of the orbit; and the nasal mucosa

oculosympathetic paresis. *See* Horner syndrome.

odontalgia pain felt in a tooth or teeth

odontogenic derived from or produced in the teeth or tissues that produce the teeth

odontogenic pain deep somatic pain arising or originating in the teeth or periodontal ligaments

olfactory nerve sensory cranial nerve (CN I) supplying the nasal mucosa

open lock. See Luxation, Subluxation.

opening

assisted mouth o. the maximal mouth opening that is attained with gentle stretching by the examiner after the patient has reached maximum unassisted mouth opening, also called passive range of motion

maximal pain-free mouth o. the maximal mouth opening that is attained without pain

maximum unassisted mouth o. the mouth opening the patient can achieve regardless of pain, also called active range of motion

ophthalmic. See Ocular.

optic nerve sensory cranial nerve (CN II) supplying the retina of the eye

oral apraxia inability to carry out purposeful oral movements in the absence of paralysis or other motor sensory impairment

organic related to the organs of the body; pertaining to an organized structure; arising from an organism

orofacial relating to the mouth and face

orthodontics specialty of dentistry dealing with the development, prevention, and correction of occlusal maxillomandibular irregularities

orthodromic impulses conducted in normal directions along nerve paths

orthognathic pertaining to malposition of the bones of the jaws

orthognathic surgery. See Surgery, orthognathic.

orthopedic relating to correction of form and function of the locomotor structures, especially the extremities, spine, and associated structures, including bones, joints, muscles, fascia, ligaments, and cartilage

orthopedic appliance. See Interocclusal appliance.

orthosis orthopedic appliance or interocclusal appliance used to support or improve function of moveable parts of the body. *Syn:*

Orthopedic appliance. See Interocclusal appliance.

orthostatic relating to an erect or upright position

orthotic. See Interocclusal appliance.

osseous bony

ossification development or formation of bone

osteoarthritis a degenerative condition of the TMJ characterized by deterioration and abrasion of articular tissue and concomitant remodeling of the underlying subchondral bone due to overload of the remodeling mechanism. *Syn:* Degenerative joint disease, Osteoarthrosis.

osteoarthrosis. See Osteoarthritis.

osteoblast bone-forming cell derived from mesenchyme

osteoblastoma benign, vascularized tumor of poorly formed bone and fibrous tissue that causes resorption of native bone. *Syn:* Giant osteoid osteoma.

osteochondral junction the interface between the calcified cartilage zone and the subchondral bone in synovial joints

osteochondritis dissecans a joint condition in which a piece of cartilage, along with a small bone fragment, breaks loose from the end of the bone, resulting in loose osteochondral fragments within the joint

osteoclast multinucleated cell that causes absorption and removal of bone

osteoma benign, slow-growing mass of mature bone, usually found on a bone and sometimes on another structure

osteomyelitis inflammation of bone, especially of the marrow, caused by pathogenic organisms

osteonecrosis a painful condition most commonly affecting the ends of long bones such as the femur

osteophyte bony outgrowth

osteoporosis thinning of bone

osteosarcoma malignant bone tumor composed of anaplastic cells derived from mesenchyme

osteotomy surgical incision or cutting through a bone

otolaryngology division of medical science concerned with diseases of the ear, larynx,

upper respiratory tract, and other associated head and neck structures

otologic pertaining to the ear

P

Paget disease disorder of unknown etiology with inflammation of one or many bones, resulting in thickening and softening of bones with unorganized bone repair; also called osteitis deformans

pain an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage⁴

p. behavior visible actions that communicate suffering or pain to others

p. detection threshold. See P. threshold.

p. disorder. See Somatic symptom disorder.

p. map a diagram showing the areas of pain on a patient

p. mediators neurovascular substances activated by noxious stimuli that trigger or sustain pain

p. modulation the suppression of pain within a nervous system network

p. pathway. See Nociceptive pathway.

p. receptor a specialized nerve ending that senses painful or harmful sensations and transmits them to a nerve

p. threshold the least experience of pain that a subject can recognize¹

p. tolerance level the greatest level of pain that a subject can tolerate¹

palatal pertaining to the roof of the mouth

palate the roof of the mouth

palliative mitigating, reducing the severity of, or denoting the elimination of symptoms without curing the underlying disease

pallidotomy a surgical procedure in which a wire probe is inserted into the globus pallidus of the brain to heat the surrounding tissue and destroy nerves with the goal of helping reduce uncontrollable movements caused by neurologic conditions such as Parkinson disease

palpation examination by feeling with the hands or fingers or to produce pain that is commonly performed during TMD evaluation

in an attempt to reproduce the patient's pain complaint

palsy paralysis or paresis

panic disorder an anxiety disorder associated with recurrent, unexpected panic attacks characterized by intense apprehension, fearfulness, or terror and often accompanied by palpitations, accelerated heart rate, sweating, tremulousness, sensations of shortness of breath, choking, chest pain, abdominal distress, nausea, dizziness, derealization, fear of dying, and fear of losing control or going crazy; at least 1 month of persistent concern about having recurrent panic attacks and a significant alteration in adaptive functioning due to such worry are included in the criteria³

panoramic radiograph circular tomography that images the jaws and related structures

parafunction nonfunctional activity; in the orofacial region, clenching and bruxing, nail biting, lip or cheek chewing, etc

paralysis palsy; loss of power or voluntary movement in muscle through injury or disease of its nerve supplies

parasympathetic nervous system division of the autonomic nervous system arising from preganglionic cell bodies in the brainstem and the middle three segments of the sacral cord; cranial nerves III, VII, and IX distribute parasympathetics to the head; cranial nerve X distributes to the thoracic and abdominal viscera via the prevertebral plexuses; and the pelvic nerve (nervus erigens) distributes its autonomic fibers to most of the large intestine and to the pelvic viscera and genitalia via the hypogastric plexus. *Syn:* Craniosacral division.

paratrigeminal syndrome. See Raeder syndrome.

paravertebral alongside or near the vertebral column

paresis partial or incomplete paralysis

paresthesia abnormal sensation, whether spontaneous or evoked; unlike dysesthesia, paresthesia includes all abnormal sensations whether unpleasant or not; dysesthesias are a subset of paresthesia specifically including those abnormal sensations that are unpleasant¹

parotid gland paired salivary gland located superficial to the masseter muscle and extending from in front of the ear to down below the angle of the mandible

paroxysm sudden sharp spasm, convulsion, or attack

paroxysmal referring to a spasm, convulsion, or sudden short-lasting onset or change in symptoms

paroxysmal hemicrania rare form of consistently unilateral headache centered around the eye and radiating to the cheek or temple, with attacks lasting 5 to 60 minutes and occurring 4 to 12 times per day for years without remission; like cluster headache, may include associated conjunctival congestion and clear nasal discharge

passive range of motion motion imparted to an articulation, associated capsule, ligaments, and muscles by another individual, machine, or outside force

passive resistive stretch activity designed to increase muscle length by activating the reciprocal muscle against an opposing force and then stretching

pathogenic condition giving rise to pathology

pathognomonic specifically distinctive or characteristic of a disease or pathologic condition; a sign or symptom on which a diagnosis can be made

pathologic indicative of or caused by a disease

pathologic condition diseased state or condition

pathophysiology the study of how normal, physiologic processes are altered by disease

pathosis misnomer. *See* Pathologic condition.

pemphigus a group of skin diseases characterized by successive crops of bullae that may leave pigmented spots after resolution and are often accompanied by itching and burning

percutaneous performed through the skin

percutaneous balloon microcompression neurosurgical procedure in which the trigeminal nerve is compressed by inflating a tiny balloon in the area of the involved nerve fibers

percutaneous glycerol rhizotomy neurosurgical procedure in which nerve fibers are destroyed by injection of anhydrous glycerol

percutaneous radiofrequency thermocoagulation neurosurgical procedure in which nerve fibers are destroyed by thermal lesioning

periarticular surrounding a joint

pericranium fibrous membrane surrounding the cranium; periosteum of the skull

periodontal trauma. *See* Occlusal trauma.

periodontalgia pain that emanates from the periodontal ligaments

periodontium the investing tissue surrounding the teeth, including the connective tissues, alveolar bone, and gingiva; anatomically used to denote the connective tissue between the tooth and the alveolar bone; also called periodontal ligament

peripheral nerve stimulation a type of neurostimulation that uses electrical signals from an implanted generator to stimulate targeted nerves that lie outside the spine to relieve pain; eg, sacral nerve stimulation

peripheral nervous system the motor, sensory, sympathetic, and parasympathetic nerves and the ganglia outside the brain and spinal cord

peripheral neurogenic pain pain initiated or caused by a primary lesion, dysfunction, or transitory perturbation in the peripheral nervous system¹

peripheral neuropathic pain pain initiated or caused by a primary lesion or dysfunction in the peripheral nervous system¹

peripheral sensitization an increased sensitivity to an afferent nerve stimuli

perpetuating factors factors that interfere with healing or exacerbate a disease process

persistent idiopathic facial pain tooth pain without obvious pathology and of unknown etiology

personality disorder disorder characterized by a long-term pattern of thinking and acting that is significantly different from the general population and results in significant adverse consequences to the individual and those around the individual

- antisocial p.d.** disorder characterized by a pervasive pattern of disregard for and violation of the rights of others described by the presence of at least three of the following: doing things that could lead to arrest, lying, not planning ahead, being irritable and aggressive to the point of getting into fights, disregarding safety of self and others, being irresponsible, and not expressing remorse or sorrow for behavior that hurts others³
- avoidant p.d.** disorder characterized by a pervasive pattern of social inhibition, feelings of inadequacy, and hypersensitivity to any criticism³
- borderline p.d.** disorder characterized by a pervasive pattern of instability of interpersonal relationships, self-image, affects, and impulsivity in action³
- dependent p.d.** disorder characterized by a pervasive and excessive need to be taken care of, leading to submissive and clinging behaviors and separation anxiety³
- histrionic p.d.** disorder characterized by pronounced emotional expression and attention-seeking behavior of often inappropriate, provocative, and sexually seductive nature³
- narcissistic p.d.** disorder characterized by a pervasive pattern of grandiosity and an intense need for the admiration of others while displaying little empathy for others³
- obsessive-compulsive p.d.** disorder characterized by a drive for perfection, orderliness, and interpersonal control, with limited openness and flexibility³
- paranoid p.d.** disorder characterized by pervasive distrust and suspiciousness of others such that their motives are interpreted as malevolent³
- schizoid p.d.** disorder characterized by a pervasive pattern of detachment from social relationships and very limited emotional expression in interpersonal settings³
- schizotypal p.d.** disorder characterized by substantial distortions of thought and very unusual behavior in addition to pervasive pattern of detachment from social relationships and very limited emotional expression³
- PET scan.** See Tomography: positron emission.
- phantom limb pain** a condition in which a patient senses that a missing body part is still attached and subsequently feels pain in that area
- pharmacotherapy** drug treatment of a disease or disorder
- pharyngeal plexus** comprises cranial nerves IX to XI and provides innervation of the pharynx as well as the upper trapezius and sternocleidomastoid muscles
- pharynx** musculomembranous sac between the mouth, nasal cavities, and esophagus
- phoenix abscess** abscess originating from a suddenly symptomatic previously dormant chronic periapical granuloma
- phonophobia** abnormal fear of or exaggerated sensitivity to sound
- photophobia** abnormal fear of or exaggerated sensitivity to light
- photopsia** the presence of perceived flashes of light, possibly associated with migraines; also associated with serious ophthalmologic conditions
- physical dependence** pharmacologic property of a drug resulting in the occurrence of an abstinence syndrome following abrupt discontinuation of the agent
- physical therapy** treatment of disease or disorder with physical and mechanical means such as massage, manipulation, exercise, heat, cold, ultrasound, and electricity; includes (re)education in correct posture, body mechanics, and movement. *Syn:* Physiotherapy.
- physiologic** pertaining to normal function of a tissue or organ. *Ant:* Pathologic.
- physiotherapy.** See Physical therapy.
- pinna.** See Auricle.
- pivot appliance** hard acrylic resin appliance with a single unilateral or bilateral posterior contact designed to provide condylar distraction
- placebo** substance, device, or behavior that superficially resembles and is believed by the patient to be an active substance, material, or behavior but has no influence

placebo effect physical or emotional change in a patient occurring after a placebo is provided, with the change not directly attributable to any specific property or effect of the substance, behavior, or therapeutic agent

planar scintigraphy two-dimensional imaging process in which the area of interest is scanned with a γ -camera 2 to 4 hours after the administration of a radioactive material; increased uptake of the radioisotope in the tissue scanned indicates an increase in cellular activity. *Syn:* Scintigraphy, Scintiscan.

platelet-aggregating factor (PAF) substance produced in the blood by the action between an antigen and immunoglobulin E-sensitized basophiles; PAF aggregates platelets and is a factor in producing inflammation

plication the stitching of folds or tucks in a tissue to reduce its size, as in the retrodiscal tissues of the TMJ or the walls of a hollow viscus

polyarthritis simultaneous inflammation of several joints

polymyalgia rheumatica self-limiting syndrome in elderly people characterized by progressive pain and stiffness of the proximal limbs after acute onset, with myalgia, fever, and an elevated ESR; onset may be unilateral but invariably becomes bilateral, resulting in successive involvement of muscle groups with morning stiffness

polyneuropathy disease involving several nerves, usually bilateral and diffuse

polysynaptic reflex a reflected movement resulting from neural conduction along a pathway formed by a chain of synaptically connected nerve cells

positive predictive value (PPV) a measure of the probability that a person has the disease, given a positive result

positron emission tomography (PET). *See* Tomography: positron emission.

posterior attachment, TMJ loose connective tissue attached to the posterior region of the fibrous portion of the articular disc and extending to and filling the posterior capsule, rich in interstitial collagen fibers, adipose tissue, arteries, and elastin, and

possessing a venous plexus. *Syn:* Retrodiscal tissue.

posterior cranial fossa the largest cranial fossa, formed by the basilar, lateral, and squamous sections of the occipital; the petrous section of the temporal; the mastoid sections of the temporal and parietal; and the posterior body of the sphenoid

posterior ligament misnomer. *See* Posterior attachment, TMJ.

posterior open bite lack of posterior tooth contact in the intercuspal position

posterior overclosure a presumed subnormal vertical dimension of occlusion due to factors such as attrition, erosion, or intrusion of posterior teeth or developmental irregularities preventing full eruption of posterior teeth. *Syn:* Overclosed bite.

postganglionic situated posterior or distal to a ganglion

postherpetic neuralgia. *See* Neuralgia: postherpetic.

postsurgical neuralgia. *See* Neuralgia: postsurgical.

posttraumatic stress disorder (PTSD) disorder characterized by the development of a specific set of symptoms following exposure to a traumatic event through direct personal experience or witnessing of an event that involves actual or threatened death or serious injury or the threat to one's physical and psychologic integrity³

postural pertaining to the attitude or position of the body

preauricular located in front of the ear

predisposing indicating a tendency or susceptibility to develop a disease or condition

predisposing factors factors that increase the risk of developing a disease or condition

preganglionic situated anterior or proximal to a ganglion

premature occlusal contact. *See* Supracontact.

prematurity. *See* Supracontact.

pretreatment records any records made for the purpose of diagnosis, recording of patient history, or treatment planning in advance of therapy

pretrigeminal neuralgia. *See* Neuralgia: pretrigeminal.

- prevalence** number of cases of a disease or disorder for a given area and population at a given point in time, usually measured as the percentage of positive cases; compare with incidence
- primary afferent nociceptor.** *See* Nociceptor: primary afferent.
- primary hyperalgesia** hypersensitivity to noxious stimuli at a site of primary nociception and tissue damage
- primary occlusal trauma** injury to the periodontium from excessive occlusal forces in teeth with normal supporting structures
- primary pain** pain located over the true source of nociceptive input
- primary stabbing headache** spontaneous short-lasting stabs of pain felt in the head, not usually unilateral or localized to one area. *Syn:* Jabs and jolts syndrome.
- principal sensory nucleus** a group of second-order neurons that have cell bodies in the caudal pons; it receives information about discriminative sensation and light touch of the face as well as conscious proprioception of the jaw via first-order neurons of cranial nerve V
- prodrome** symptom indicating the onset of a disorder
- prognathic** having a forward-projecting jaw. *Syn:* Prognathous.
- prognosis** a prediction of the course of the outcome of a disease or condition
- progressive supranuclear palsy** spastic weakness of facial, masticatory, and oropharyngeal muscles due to a lesion in the corticospinal tract; may cause spontaneous laughing or crying. *Syn:* Pseudobulbar paralysis, Spastic bulbar palsy, Supranuclear paralysis.
- projected pain** neurogenic pain that is felt in the anatomical peripheral distribution of a nerve while the stimulus occurs along the pathway from the nerve to the cortex
- proprioception** reception and interpretation of stimulation of sensory nerve terminals within the tissues of the body that provides information concerning movements and positions of the body
- prostaglandins** fatty acids that serve as extremely active biologic substances, with effects on the cardiovascular, gastrointestinal, respiratory, and central nervous systems
- prosthesis** cosmetic or functional artificial substitute of a missing body part, including teeth, eyes, and limbs
- prosthetic** pertaining to the replacement of a missing body part or augmentation of a deficient part by an artificial substitute
- protective muscle splinting** reflexive contraction of adjacent muscles resulting from noxious stimuli of a sensory field of a joint, soft tissue, or other structure to prevent movement or provide stabilization to the painful surrounding tissues; differs from muscle spasm in that the contraction is not sustained when the muscle is at rest. *Syn:* Muscle guarding, Protective cocontraction, Reflex muscle splinting.
- proteoglycan** mucopolysaccharides bound to protein chains in covalent complexes within the extracellular matrix of connective tissue
- protrusion** state of being thrust forward or projected; in the head and neck area, reflects movement of the mandible forward of the intercuspal position
- protrusion of mandible** anterior mandibular movement with bilateral forward condylar translation
- provisional appliance** any appliance for time-limited use
- provocation test** diagnostic method of attempting to induce a disease episode or aggravate a symptom by provoking a tissue or system
- proximal** closer to a point of reference. *Ant:* Distal.
- pseudoaddiction** phenomenon resembling typical behaviors associated with addiction but due to undermedication of an identifiable pain complaint; behaviors will cease when pain is adequately controlled
- pseudoankylosis** a false ankylosis. *See* Adhesion: intracapsular.
- pseudobulbar paralysis.** *See* Progressive supranuclear palsy.
- pseudogout.** *See* Chondrocalcinosis.
- psoriatic arthritis** polyarticular, progressive erosive joint inflammation with associated scaly, red skin lesions and usually involving the distal interphalangeal joints

psychoactive medication drug that affects the mental functioning of an individual

psychogenic pain disorder. *See* Somatic symptom disorder.

psychomotor retardation a slowing of both thoughts and physical activity often seen with depression and other psychiatric disorders

psychosocial involving both psychologic and social aspects of functioning

psychosomatic referring to both mind and body; pertaining to the influence of the mind or higher functions of the brain (emotions, fears, desires, etc) on the functions of the body, especially in relation to bodily disorders or disease

psychotic pertaining to severe mental disorders characterized by disorganized thought processes and loss of reality testing; such illnesses typically include hallucinations, delusions, disorganized speech, and grossly impaired adaptive functioning

psychotropic medication. *See* Psychoactive medication.

ptosis prolapse or drooping of an organ or part; for example, the upper eyelid due to altered third cranial nerve function or cervical sympathectomy

eyelid p. droopiness of the upper eyelid as seen in Horner syndrome; functional deficit of the levator palpebrae superior due to palsy of the oculomotor nerve; ptosis may also be a sign of other syndromes

pulpal pain odontogenic pain that emanates from the dental pulp

pulpitis inflammation of the dental pulp

pumping procedure passive joint mobilization after intracapsular addition of fluid into the joint

pyrophosphate arthropathy. *See* Chondrocalcinosis.

R

radiculalgia pain in the distribution of one or more sensory nerves

radiculitis inflammation of one or more nerve roots.⁴ *See* Radiculopathy.

radiculopathy a disturbance of function or pathologic change in one or more nerve

roots⁴; disease of a nerve that results from mechanical nerve root compression and may lead to pain, numbness, weakness, and paresthesia

radiofrequency lesioning uses high-frequency energy to produce heat and thermal coagulation of affected nerves to disrupt their ability to transmit pain signals

radiograph image of internal structures produced by radioactive rays striking a sensitized film after passing through a body part

radionuclides atoms that disintegrate with emission of electromagnetic radiation, used in radiographic studies

radiopaque not permitting the passage of radiation energy and registering white or light on radiograph

radiovisiography (RVG) digital imaging technique using radiation but not film, with computer storage of images

Raeder syndrome characterized by severe, unilateral craniofacial pain or dysesthesia that is usually in the V1 or V2 distribution. *Syn:* Paratrigeminal syndrome.

Ramsay Hunt syndrome. *See* Neuralgia: geniculate.

range of motion (ROM) the range, typically measured in degrees of a circle, through which a joint can be extended or flexed; with reference to the TMJ, usually reported as millimeters of interincisal distance

rapid eye movement (REM) active stage of deep sleep, characterized by prominent increase in the variability of heart rate, respiration, and blood pressure, including periods of rapid eye movements and muscle twitching; the stage of sleep during which dreaming and muscle hypotonia occurs

reciprocal clicking. *See* Clicking joint noise, TMJ: reciprocal.

recruitment of muscle gradual increase in the number of active muscle units to a maximum in response to prolonged stimulus

red ear syndrome rare disorder of unknown etiology that has the defining symptoms of redness of one or both external ears accompanied by a burning sensation

reducing disc. *See* Disc displacement: with reduction.

- reduction** restoration of a part to its normal anatomical location by surgical or manipulative procedures; eg, a fracture or dislocation
- referral zone** site at which referred (heterotopic) pains or symptoms are perceived
- referred pain** pain perceived in a site distant from the nociceptive source. *Syn:* Heterotopic pain.
- reflex** the sum total of any particular involuntary activity
- reflex muscle splinting.** See Protective muscle splinting.
- reflex sympathetic dystrophy (RSD)** sympathetically maintained burning and hyperesthetic deafferentation pain typically initiated by trauma or surgical procedure, often accompanied by vasomotor, sudomotor, and later trophic changes in the skin; preferred term: complex regional pain syndrome. *Syn:* Causalgia, Shoulder-hand syndrome, Sudeck atrophy.
- refractory** resistant to treatment
- refractory period** a period of time during which pain cannot be triggered again
- Reiter syndrome** triad of polyarticular arthritis, urethritis, and conjunctivitis that usually follows nonspecific nongonococcal urethritis, predominantly in men; may be associated with stomatitis and ulceration of the glans penis
- remodeling** adaptive alteration of tissue form in response to functional demands through a cellular response of articular fibrocartilage and subchondral bone
- repositioning appliance.** See Anterior repositioning appliance, mandibular.
- repositioning, jaw** the changing of any relative position of the mandible to the maxilla, usually through alteration of the occlusion of the natural or artificial teeth or through the use of an interocclusal appliance
- resorption** loss of tissue substance by physiologic or pathologic processes
- restorative sleep** See Sleep; restorative.
- retrodiscal pad** misnomer. See Posterior attachment, TMJ.
- retrodiscal tissue.** See Posterior attachment, TMJ.
- retrodiscitis** inflammation of the retrodiscal tissues within the TMJ
- retrognathia** facial disharmony in which the jaw, usually the mandible, is receded posterior to normal in their craniofacial relationship
- retruded contact position (RCP)** point of initial tooth contact when the condyles are guided along the posterior slope of the articular eminence into their most superior position on jaw closure. *Syn:* Centric relation, Centric relation occlusion.
- retrusion** posterior location or movement; in the orofacial region, posterior positioning of a tooth or mandible from normal
- retrusion of mandible** posterior mandibular movement with bilateral retrusive condylar translation
- reversible treatment** any therapy that does not cause permanent change
- review of systems (ROS)** system-by-system review of body functioning while completing the health history and physical examination
- rheumatic** pertaining to rheumatism
- rheumatism** a group of disorders characterized by degeneration, metabolic change, or inflammation of the connective tissues, particularly those associated with muscles and joints
- rheumatoid arthritis** chronic polyarticular erosive inflammatory disease, more common in women, characterized by bilateral involvement with proliferative synovitis, atrophy, and rarefaction of bones
- rheumatoid factor (RhF)** anti- γ globulin antibodies found in the serum of most patients with rheumatoid arthritis but also found in a small percentage of apparently normal patients as well as patients with other collagen vascular diseases, chronic infections, and noninfectious diseases
- rhizotomy** an operation to cut or destroy nerve fibers close to the spinal cord to relieve chronic pain or treat movement disorders that have not responded to more conservative treatments
- risk factor** factor that causes an individual or a group to be vulnerable to a disease or disorder, resulting in increased incidence or severity for the susceptible population

rostral. *Syn:* Superior; *Ant:* Caudal. *See* Cephalad.

rostrum beaklike appendage or part

S

sagittal pertaining to an anteroposterior plane or section parallel to the long axis of the body

sagittal plane vertical reference plane parallel to the long axis of the body, situated in an anterior-posterior direction, dividing the body into right and left halves

saline solution containing sodium chloride and purified water

sarcoidosis chronic progressive disease of unknown cause marked by granulomatous lesions in the skin, lymph nodes, salivary glands, eyes, lungs, and bones

scintigraphy. *See* Planar scintigraphy.

scintillation perception of twinkling light of varying intensity that can occur during a migraine aura

s. detector device for measuring radioactivity that relies on the emission of light or ultraviolet radiation from a crystal subjected to ionizing radiation

scintiscan. *See* Planar scintigraphy.

scleroderma disease characterized by thickening and hardening of connective tissue in any part of the body, including skin, heart, lungs, and kidneys; skin may be thickened and hard with pigmented patches. *Syn:* Systemic sclerosis.

scotoma isolated area of varying size and shape within the visual field in which vision is absent or depressed

secondary gain indirect benefit, usually obtained through an illness or debility, that allows an individual to avoid responsibility or an activity that is noxious to him or her and/or to obtain support from others that would not ordinarily be forthcoming

secondary hyperalgesia increased sensitivity to normally painful stimuli outside and surrounding a zone of primary hyperalgesia

secondary occlusal trauma injury to the periodontium from excessive occlusal forces in teeth already affected with periodontal disease

secondary pain. *See* Referred pain.

sedimentation rate. *See* Erythrocyte sedimentation rate.

sella turcica a saddle-shaped section of the sphenoid bone located in the middle cranial fossa that houses the pituitary gland

sensitivity a measure of how well a certain test is able to identify a disease when the disease is actually present, also called the true positive rate; if a highly sensitive test is negative, it rules out the disease

sensitization the increased sensitivity of afferent receptors following repeated application of a noxious stimulus; a lowering of the pain threshold; psychologically, a defensive hyperarousal, induced by repetitive exposure to a noxious stimulus; also, development of lowered pain threshold in unstimulated undamaged regions adjacent to an area of primary nociception and hyperalgesia. *Syn:* Secondary hyperalgesia.

sensory nerve afferent fibers of a peripheral nerve that conduct sensory impulses from the periphery of the body to the brain or spinal cord

serology study of in vitro antigen-antibody reactions

serotonergic encouraging the production of serotonin; cells that contain or are activated by serotonin

serotonin biogenic amine produced from tryptophan; found in serum and many other tissues, including mucosa, pineal body, and the central nervous system; acts as a vasoconstrictor, neurotransmitter, and pain-sensitizing agent. *Syn:* 5-hydroxytryptamine, 5-HT.

shingles misnomer. *See* Herpes zoster.

shoulder-hand syndrome. *See* Reflex sympathetic dystrophy.

sialography radiographic technique in which a salivary gland is filmed after an opaque substance is injected into its duct

sign any objective evidence of a disease

silent period, masticatory muscle momentary electromyographically observable decrease in elevator muscle activity on initial tooth contact, presumably the inhibitory effect of stimulated periodontal membrane receptors

single-photon emission computed tomography (SPECT). See Tomography: single-photon emission computed.

sinusitis inflammation, either purulent or non-purulent, of the mucosa of the sinuses

sinuvertebral nerve formed by mixed spinal and sympathetic branches that anastomose contralaterally; provides innervation to the vertebral periosteum, outer fibers of the annulus fibrosus, posterior longitudinal ligament, dura mater, and epidural blood vessel walls. *Syn:* Recurrent meningeal nerve.

Sjögren syndrome idiopathic collagen disorder, more common in middle-aged or older women, that is characterized by atrophic changes of the lacrimal and salivary glands, resulting in dryness of the eyes and mouth, sometimes associated with polyarthritis

skeletal pertaining to the bony, hard framework of the animal body

sleep

nonrestorative s. sleep that leaves the individual feeling unrefreshed upon awakening

restorative s. sleep that leaves the individual feeling refreshed, rested, and reenergized

s. apnea breathing abnormality during sleep, characterized by cessation of airflow secondary to a lack of respiratory effort; commonly related to upper airway obstruction but may be related to central causes

SNOOP4 mnemonic tool of the American Headache Society that outlines aspects of a patient's signs and symptoms that indicate a severe or life-threatening disorder

soft tissue nonbony or noncartilaginous tissue, including muscles and their fascial envelopes, tendons, tendon sheaths, ligaments, joint capsule, bursae, fat, skin, etc

somatic pertaining to the body as distinct from the mind or psyche; pertaining to the structures of the body wall; eg, skeletal tissue in contrast with visceral structures

somatic pain pain resulting from tissue damage and the subsequent release of chemicals that act as noxious stimuli that are perceived by the brain as pain; also called nociceptive pain

somatic symptom disorder diagnosis is made based on the signs and symptoms of distressing somatic symptoms plus abnormal thoughts, feelings, and behaviors in response to the somatic symptoms, rather than the absence of a medical explanation for the somatic symptoms; the prominent characteristic of these individuals is not the somatic symptoms, but the way these individuals present and interpret them

somatization in psychiatry, the process whereby a mental condition is experienced as a bodily symptom

somatosensory related to somatic afferent neural systems

sonography. See Ultrasonography.

space-occupying lesion abnormal mass or tumor that distends adjacent tissue as it enlarges

spasm, muscle involuntary, sudden reversible tonic contraction of a muscle

spastic bulbar palsy. See Progressive supranuclear palsy.

specificity a measure of how well a test, when negative, identifies those who do not have the disorder, also called the true negative rate; a test with high specificity, when positive, can rule in the disease

SPECT. See Tomography: single-photon emission computed.

speculum appliance that allows for opening a body cavity or passage for inspection

sphenoid bone compound, unpaired wedge-shaped bone at the base of the cranium, separating the frontal and ethmoid bones and the maxilla frontally from the temporal and occipital bones. *Syn:* Sphenoid.

sphenopalatine ganglion a parasympathetic ganglion found in the pterygopalatine fossa; it is largely innervated by the greater petrosal nerve (a branch of the facial nerve), and its axons project to the lacrimal glands and nasal mucosa. *Syn:* Meckel ganglion, Pterygopalatine ganglion.

spheroidal joint. See Enarthrosis joint.

spinal accessory cranial nerve motor cranial nerve (CN XI) comprising cranial and spinal branches that supply the trapezius and sternocleidomastoid muscles and the pharynx

spinal anesthesia type of medication that produces temporary loss of sensation below the area of injection into the spinal cord without loss of consciousness; also called epidural anesthesia

spinal cord stimulation electrical stimulation of nervous tissues on a specific portion of the spinal cord to produce paresthesia

spinal nerves nerves that emerge from the spinal cord and innervate the organs and tissues; there are 31 pairs of spinal nerves, each attached to the cord by two roots, ventral and dorsal

spinal trigeminal nucleus one of the nuclei of the trigeminal nerve, consisting of three subnuclei: subnucleus oralis, subnucleus interpolaris, and subnucleus caudalis. *Syn:* Medullary dorsal horn.

spine. *Syn:* Spinal column, Vertebral column.

splint. *See* Interocclusal appliance.

splinting, muscle. *See* Protective muscle splinting.

spondyloarthropathy disease of the spinal or intervertebral articulations

spondylosis. *See* Ankylosing spondylitis.

spontaneous remission resolution of signs or symptoms of disease occurring unaided and without treatment

spray and stretch physical therapy technique using vapocoolant spray followed by passive muscle stretch

Spurling test used in confirming the diagnosis of cervical radiculopathy; involves side bending and extending the patient's head to the side of involvement, and pressure may or may not be applied; the finding is positive if the patient's upper extremity paresthesia or pain is intensified or reproduced

stabilization appliance a flat-plane intraoral appliance fitted over either the maxillary or mandibular teeth without significant mandibular repositioning, used to control joint or muscle symptoms or to protect against damage or injury to the teeth or prosthetic placements

standard of care established model or guidelines of diagnostic and therapeutic management in a given community or setting

status migrainosus severe unrelenting migraine headache associated with nausea

and vomiting that lasts longer than 72 hours; may not be manageable under outpatient care

stellate ganglion star-shaped sympathetic ganglion located between the transverse process of the seventh cervical vertebra and the head of the first rib, with postganglionic fibers running to the carotid, middle ear, salivary, and lacrimal glands, and the ciliary ganglion via cranial nerves IX, X, and XI and the upper three cervical nerves

stenosis narrowing or stricture of a duct or canal

stent device used to hold medication in contact with a mucosal site, hold a skin or mucosal graft in place, provide support for tubular structures, or facilitate radiation therapy

antihemorrhagic s. controls bleeding during surgery

burn s. minimizes contraction of burned tissue during healing

medication s. holds topical medication in contact with a mucosal site

nasal s. supports the form of the nose

palatal s. protects a palatal surgical site during healing or keeps a mucosal flap or skin graft in close apposition to the surgical bed

radiation s. used in the process of delivery of radiation therapy; protects healthy tissues, displaces such tissues away from the field of radiation, or directs the radiation beam to the target site

stethoscope instrument for performing mediate auscultation

stereotactic neurosurgery. *See* Gamma knife surgery.

stereotactic radiosurgery. *See* Gamma knife surgery.

Still disease seronegative arthritis, often accompanied by fever and lymphadenopathy, representing 70% of cases of arthritis that begin before the age of 16 years. *Syn:* Juvenile rheumatoid arthritis.

stimulation the action of a stimulus on a receptor

stimulation coverage the amount of a patient's pain pattern that is converted by stimulation

stimulus anything that arouses action in the muscles, nerves, or other excitable tissue

stomatognathic denoting the mouth and jaws collectively

stomatognathic system the functional and anatomical relationships among the teeth, jaws, TMJs, and muscles of mastication

stomatology study of structures, functions, and diseases of the mouth

strabismus. See Heterotropia.

stress the challenge for adaptation created by the sum of physical, mental, emotional, internal, or external stimuli that tend to disturb the homeostasis of an organism; inappropriate reactions can lead to disease states

stressor cause of stress; any factor that disturbs homeostasis

study cast. See Cast, dental.

study model. See Cast, dental.

stump pain pain located in the amputated limb's remaining stump

subchondral beneath cartilage

subchondral bone bone beneath cartilage

subcutaneous beneath the skin

sublingual pertaining to the regions or structures beneath the tongue

subluxation, TMJ a condition in which the disc-condyle complex is anterior to the articular eminence and is unable to return to the mandibular fossa without a maneuver by the patient

submandibular situated below the mandible

subnucleus caudalis one of the subnuclei of the spinal trigeminal nucleus; the main terminus for most slow first-order neurons conveying potential pain impulses from trigeminal receptive fields

subnucleus interpolaris one of the subnuclei of the spinal trigeminal nucleus that receives some peripheral nociceptive input but mostly relays temperature and touch impulses

subnucleus oralis (SNO) one of the subnuclei of the spinal trigeminal nucleus that receives some peripheral nociceptive input but mostly relays temperature and touch impulses

Sudeck atrophy. See Reflex sympathetic dystrophy.

suffering a state of severe distress associated with events that threaten the intactness of the person; may be associated with pain

summation progressive increase of pain intensity with repeated noxious stimulation; depends on activity in unmyelinated nociceptors

SUNCT syndrome short-lasting, unilateral, neuralgiform pain with conjunctival injection and tearing

superior. See Cephalad.

superior laryngeal neuralgia. See Neuralgia: superior laryngeal.

superior retrodiscal lamina the most superior surface of the retrodiscal tissues or posterior attachment

superior sagittal sinus one of a series of venous sinuses situated between the meningeal and endosteal layers of the dura mater that drain blood from the brain and cranial bones; the superior sagittal sinus attaches to the falx cerebri and enlarges posteriorly at the internal occipital protuberance to form the confluence of sinuses

supraclusion occlusal relationship where an occluding surface extends beyond the normal occlusal plane. *Syn:* Overeruption of teeth.

supracontact posterior occlusal contact before maximal intercuspation. *Syn:* Premature occlusal contact, Prematurity; Misnomers: Interceptive occlusal contact, Occlusal interference.

supranuclear paralysis. See Progressive supranuclear palsy.

surgery, orthognathic surgical repositioning of all or parts of the maxilla or mandible to correct malpositions or deformities

symmetry correspondence in size, shape, and relative position around an axis or on each side of a plane of the body. *Ant:* Asymmetry.

sympathectomy excision or interruption of some portion of the sympathetic nervous system pathway. *Syn:* Sympathetic neurolysis.

sympathetic pertaining to the sympathetic nervous system

sympathetic nervous system division of the autonomic nervous system originating in

the thoracic and upper three or four lumbar segments of the spinal cord, responsible for the regulation of vasomotor tone, temperature, blood sugar levels, and other aspects of the “fight or flight” reaction to stress. *Syn:* Thoracolumbar division.

sympathetic neurolysis. *See* Sympathectomy.

sympathetically maintained pain pain sustained through activity of the sympathetic nervous system; may accompany disorders such as complex regional pain syndrome and reflex sympathetic dystrophy

symphysis the fused immovable cartilaginous junction between two originally distinct bones. *Syn:* Fibrocartilaginous joint.

mandibular s. the midline symphysis of the right and left halves of the fetal mandible

symptom any subjective experience perceived as evidence of a disease by a patient

Symptom Check List Revised, 90-item (SCL-90-R) 90-item multidimensional self-report measure of nine dimensions of psychologic functioning

synapse junction between the processes of two adjacent neurons where a neural impulse is transmitted from one neuron to another. *Syn:* Synaptic junction.

synaptic junction. *See* Synapse.

syndrome set of symptoms or signs that together define a disorder

synkinesis unintentional movement accompanying a volitional movement

synostosis. *See* Ankylosis: bony.

synovia clear, thick lubricating fluid in a joint, bursa, or tendon sheath secreted by the membrane lining the cavity or sheath. *Syn:* Synovial fluid.

synovial pertaining to or secreting synovia

synovial chondromatosis rare condition in which cartilage nodules develop in the connective tissue below the synovial membranes; the cartilage foci on the surface of the synovium may detach and result in loose bodies within the joint. *Syn:* Synovial osteochondromatosis.

synovial fluid. *See* Synovia.

synovial joint joint possessing a synovial lining

s.j. lining membrane lining synovial joints that secretes synovia

synovial osteochondromatosis. *See* Synovial chondromatosis.

synovitis inflammation of the synovial lining of a joint due to infection, an immunologic condition, or secondary to cartilage degeneration or trauma; usually painful, especially with movement

syringomyelia characterized by longitudinal cavities (syrinx) within the spinal cord that cause pain and paresthesia, atrophy of the hands and lower extremities, and spastic paralysis

systemic arthritides joint inflammation resulting in pain or structural changes caused by a generalized systemic inflammatory disease, including rheumatoid arthritis, juvenile idiopathic arthritis, spondyloarthropathies, and crystal-induced disease

systemic disease disease affecting the entire organism as distinguished from any of its individual parts

systemic lupus erythematosus (SLE) generalized connective tissue disorder affecting primarily middle-aged women, causing among other things, lesions of the skin, vasculitis, arthralgia, and leukopenia; usually associated with evidence of autoimmune dysfunction such as elevated antinuclear antibodies

systemic sclerosis. *See* Scleroderma.

T

tachycardia excessively rapid pulse rate (ie, >100 beats/min)

tardive dyskinesia involuntary, repetitious movements of the muscles of the face, limbs, and trunk, most often related to the use of neuroleptic medications and persisting after withdrawal

teichopsia a transient visual sensation of bright shimmering colors

temporal pertaining to the temples; also, limited in time

temporal arteritis. *See* Arteritis.

temporal bone paired, irregular bone forming part of the lower and lateral surfaces of the cranium; consists of four portions: mastoid,

- squama, petrous, and tympanic; contains the hearing apparatus
- temporomandibular** relating to the TMJ
- temporomandibular disorders (TMDs)** a number of clinical problems that involve the masticatory muscles, the TMJ, or both
- temporomandibular joint (TMJ)** paired synovial joint capable of both gliding and hinge movements, articulating the mandibular condyle, articular disc, and squamous portions of the temporal bone
- t.j. dysfunction** abnormal, incomplete, or impaired function of the TMJ(s)
- t.j. hypermobility** excessive mobility of the TMJ
- t.j. syndrome** misnomer. See Temporomandibular disorders.
- tendomyositis** inflammatory condition of a tendon and its associated muscle
- tendon** strong, flexible, and inelastic fibrous band of tissue attaching muscle to bone
- tendonitis** pain within a tendon affected by jaw movement, function, or parafunction, and replication of this pain with provocation testing of the masticatory tendon
- TENS.** See Transcutaneous electrical nerve stimulation.
- tension** act or condition of being stretched, strained, or extended. *Syn:* Stress.
- tension-type headache (TTH)** dull, aching, pressing, usually bilateral headache of mild to moderate intensity; when severe, may include photophobia or phonophobia and, rarely, nausea; may be intermittent, lasting minutes to days, or chronic without remission
- chronic t.h.** average of 15 or more headache days per month for at least 3 months
- frequent episodic t.h.** number of headache days averages more than 1 but less than 15 per month for at least 3 months
- infrequent episodic t.h.** number of headache days averages less than 1 per month
- probable t.h.** headaches fulfilling all but one of the criteria for specified type
- tentorium cerebelli** fascial membrane that separates the cerebellum from the cerebral hemispheres and forms a crescent-shaped tent or roof to the posterior cranial fossa
- therapeutic** relating to treatment or the art of healing; producing improvement or cure of an illness
- therapeutic prosthesis** prosthesis used to transport and retain some agent for therapeutic purposes
- thermography** technique using an infrared camera that provides a graphic representation of the skin temperature variations between adjacent tissues or between the same area on two sides of the body
- thoracic outlet syndrome (TOS)** condition in which pressure exerted on nerve roots in the thoracic area (including the brachial plexus) causes pain
- threshold** smallest stimulus that can be perceived; the minimum level required to produce a result
- thunderclap headache** abruptly starting headache, reaching most severe intensity usually within 1 minute and lasting from 1 hour to 10 days
- tic douloureux.** See Neuralgia: trigeminal.
- tidemark** the demarcation line between the calcified cartilage zone and the fibrocartilaginous zone of synovial joints
- time-contingent treatment.** See Clock-regulated treatment.
- tinnitus** presence of any subjective noise, such as a ringing, buzzing, or roaring sound in the ear or head
- TMJ.** See Temporomandibular joint.
- tolerance** physiologic state requiring increasing doses of agents to produce a sustained desired effect
- tomography** radiographic technique that shows structural images of the internal body lying within a predetermined plane of tissues while blurring or eliminating images of structures lying in other planes
- computed t. (CT)** imaging method that uses a narrowly collimated radiographic beam that passes through the body and is recorded by an array of scintillation detectors; the computer calculates tissue absorption, with the film images reflecting the densities of various structures. Misnomers: CAT scan,

Computer-assisted tomography, Computerized axial tomography, Computerized tomography, Computerized transaxial tomography.

cone-beam computed t. (CBCT) imaging method that uses divergent radiographic beams, thus forming a cone; provides transaxial, axial, and panoramic images that can be reconstructed in two- and three-dimensional layers

focal plane t. imaging method that shows a detailed cross section of a body part at a predetermined depth and thickness of cut; accomplished by moving the film and the x-ray source in opposite directions during the exposure, blurring the structures in front of and behind the area of interest

positron emission t. (PET) imaging method based on detection of positron emission from decaying radionuclides within a patient; provides information on both tissue density and metabolism

single-photon emission computed t. (SPECT) imaging method based on detection of single g photons emitted by radionuclides within a patient; provides information on location of these radionuclides, which, depending on the type of scan desired, are taken up by inflammatory cells or metabolizing bone cells, etc

torticollis contracted state of cervical muscles producing twisting of the neck and an unnatural head posture

spasmodic t. intermittent torticollis due to tonic, clonic, or tonicoclonic spasm in cervical muscles

Tourette syndrome syndrome with juvenile onset and including facial tics; purposeless, uncoordinated, voluntary movements; and involuntary vocalisms. *Syn:* Gilles de la Tourette syndrome.

Towne radiograph fronto-occipital plain film projection of the skull, with the patient supine and chin depressed; allows visualization of the occipital and petrous bones as well as condyles of the mandible

transcranial radiograph plain-film projection of the contralateral TMJ condyle from a superoposterior angulation

transcutaneous electric nerve stimulation (TENS) low-voltage electrical stimulation used as therapy

translation of condyle mandibular condylar movement that occurs during protrusion, lateral excursion, or mouth opening, primarily involving the superior aspect of the disc and the articular tubercle; usually mixed with some degree of condylar rotation. *Syn:* Gliding of condyle, Sliding condylar movement.

transverse plane horizontal plane dividing the body into upper and lower portions

trauma an injury or wound to a part of the living body; also, acute or chronic psychologic shock that exceeds the individual's coping capacities and that may cause lasting deleterious effects on the personality

macrotrauma injury to the body from an external source, involving large or excessive force

microtrauma repetitive, low-level, potentially injurious force to the body, usually internal to the organism, as with chronic habits such as poor posture or clenching of the teeth

traumatic arthritis arthritis that is the direct result of a macrotrauma, affecting normal joints or aggravating existing joint disease or derangement

Treacher Collins syndrome inherited disorder characterized by mandibular and facial dysostosis

treatment plan the sequence of procedures planned for a patient's treatment after a diagnosis

tremor involuntary trembling or quivering, repetitive and rhythmic

essential t. benign hereditary familial extrapyramidal tremor; worsens with age and stress

movement-induced t. tremor triggered by a particular body movement

parkinsonian t. slow tremor associated with Parkinson disease; worse with cold, fatigue, and stress

resting t. tremor at rest that disappears with body movement. *Syn:* Static tremor.

static t. *See* Resting t.

trigeminal autonomic cephalalgias (TACs) a group of headaches characterized by the presence of autonomic features

trigeminal nerve mixed cranial nerve (CN V) comprising three main branches: ophthalmic (V1), maxillary (V2), and mandibular (V3); responsible for somatosensory innervation of structures embryologically derived from the first brachial arch, including the oral cavity and the face; the motor fibers principally supply the muscles of mastication as well as the mylohyoid, anterior belly of the digastric, the tensor veli palatini, and the tensor tympani muscles

trigeminal neuralgia (TN). *See* Neuralgia: trigeminal.

trigger point (TP) a hypersensitive area in muscle or connective tissue that, when palpated, produces pain. *See* Myofascial trigger point.

trismus condition of being unable to open the mouth fully; may be due to multiple conditions, including but not limited to spasm of masticatory muscles, early symptom of tetanus, inflammatory response (ie, pericoronitis), or radiation therapy. *Syn:* Mandibular trismus.

trochlear nerve motor cranial nerve (CN IV) supplying the superior oblique muscle of the eye

trophic pertaining to nutrition or nourishment

tubercle characteristic lesion of tuberculosis; nodule on skin or bone. *See* Eminence.

tumor. *See* Neoplasm.

U

ultrasonic referring to ultrasound

ultrasonography visualization of deep structures of the body by directing ultrasonic waves into the tissues and recording the reflections. *Syn:* Sonography.

ultrasound sound waves (mechanical radiant energy) beyond the upper frequency limit of the human ear (> 20,000 vibrations per second Hz)

uncinate processes located in the cervical region of the spine between C3 and C7 and formed by uncinate processes that are located laterally on the vertebral body, which

project upward from the vertebral body below and downward from the vertebral body above and allow for flexion and extension and limit lateral flexion in the cervical spine; though referred to as joints, they are not true diarthrodial joints. *Syn:* Joints of Luschka.

unilateral occurring on one side only. *Ant:* Bilateral.

urate crystal salt of uric acid that may be deposited in gouty joints

V

vagus nerve mixed cranial nerve (CN X) that exits the cranium via the jugular foramen and supplies sensory fibers to the ear, tongue, pharynx, and larynx; parasympathetic and visceral afferents to the viscera; as well as motor fibers to the muscles of the pharynx, esophagus, and larynx

vapocoolant spray highly volatile liquid that evaporates quickly when sprayed on warm skin, causing immediate cooling; used in spray-and-stretch therapy

vapocoolant spray–stretch procedure. *See* Spray and stretch.

vascular pertaining to a blood vessel

vascular pain deep somatic pain of visceral origin that emanates from the afferent nerves that innervate blood vessels

vasculitis inflammatory condition of a blood vessel

vasoconstriction narrowing of blood vessels, causing reduced blood flow to part of the body

vasodilatation widening of blood vessels, causing increased blood flow to part of the body

vasomotor effecting changes in the diameter of a blood vessel

vasospasm sudden decrease in the internal diameter of a blood vessel, caused by the contraction of the muscle within the wall of the vessel, resulting in decreased blood flow

vertical dimension of occlusion (VDO) vertical distance between any two arbitrary points when the teeth are in intercuspal

position; one point is on the mandible and the other is on the face

vertical plane sagittal or frontal plane; perpendicular to the transverse plane

vertigo hallucination of movement; a sensation as if the external world were revolving around the patient (objective vertigo) or as if the patient were revolving in space (subjective vertigo); sometimes erroneously used as a synonym for dizziness; vertigo may result from disease of the inner ear; from cardiac, gastric, or ocular disorders; from organic brain disease; or from other causes

vestibular nucleus a cluster of nerve cells within the medulla that has extensive neuronal connections to and from the head, neck, trunk, eyes, and ears, serving to coordinate reflexive control of balance, gaze, equilibrium, and posture; descending tracts synapse within the cervical spine and represent another aspect of the relationship between the head and neck

vibration analysis method to measure minute vibrations of the condyle on translation to aid with the diagnosis of internal derangements

visceral pain deep somatic pain that originates in visceral structures, such as mucosal linings, walls of hollow viscera, parenchyma of organs, glands, dental pulps, and vascular structures

W

Waldeyer tonsillar ring ring of lymphoid tissues surrounding the upper airway, consisting of adenoid, tubal, palatine, and lingual tonsils

Wallerian degeneration a process that results when a nerve fiber is cut or crushed and the part of the axon distal to the injury (ie, farther from the neuron's cell body) degenerates

whiplash misnomer. *See* Flexion-extension injury.

windup repetitive nerve stimulation leading to exuberant response in the central nervous system

X

xerostomia subjective dryness of the mouth

x-ray. *See* Radiograph.

Z

zoster. *See* Herpes zoster.

zygapophyseal the articulation (moving) of facet joints of the spine that enable extension, flexion, and rotation. *Syn:* Facet joint.

zygoma area formed by the union of the zygomatic bone and the zygomatic process of the temporal bone and the maxillary bone

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Table G-1 Terms to avoid and preferred terms

| Terms to Avoid | Preferred Terms |
|--------------------------------------|---|
| arthritis deformans | rheumatoid arthritis |
| bilaminar zone | posterior attachment |
| bite guard | stabilization appliance |
| computer-assisted tomography | computed tomography |
| computerized axial tomography | computed tomography |
| computerized transaxial tomography | computed tomography |
| CT scan | computed tomography |
| disk | disc |
| fibrositis | fibromyalgia |
| flat-plane appliance | stabilization appliance |
| locked joint | disc displacement without reduction with limited opening or closed lock |
| meniscectomy, TMJ | discectomy |
| meniscus, TMJ | intra-articular disc |
| muscle cramp | spasm |
| muscle relaxation appliance | stabilization appliance |
| myofascial pain dysfunction syndrome | temporomandibular disorders |
| pathosis | pathologic condition |
| posterior ligament | posterior attachment |
| psychogenic pain disorder | somatoform disorder |
| reflex sympathetic dystrophy | complex regional pain syndrome |
| retrodiscal pad | posterior attachment |
| shingles | herpes zoster |
| sliding condylar movement | translation of condyle |
| temporomandibular joint syndrome | temporomandibular disorders |
| whiplash | flexion-extension injury |

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